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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 erg/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 1, January 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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Department of Commerce
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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
Environmental Control Administration
Bureau of Radiological Health

Reports

Radiation Doses to Children's Thyroids from Iodine-131 in Milk

Robert H. Neill and *Paul B. Robinson* [1]

Measurements of iodine–131 in milk taken since 1957 were used to estimate the average cumulative radiation doses to children born and living in selected U.S. cities. The cumulative doses were summed for a cohort (born in a particular year and city) from quarterly doses calculated by varying thyroid weight, uptake factor, and milk consumption, as a function of the age of the child and concentrations of iodine–131 in milk as a function of time and location. Average values of these variables were selected for each quarter.

For a given concentration of iodine–131 in milk, the population receiving the greatest dose are milk-drinking infants of 6 to 11 months of age. Considerable variation was found to exist in cumulative doses for children raised in different cities. Within a particular city, there is a large variation in thyroidal doses for children born in different years.

The largest doses were 1,750 mrem and 1,625 mrem, received by children born in 1957 in St. Louis and Salt Lake City. At the time of the cessation of weapons testing in 1963, the average child of 6 years of age in four of the five U.S. cities where data are available had received man-made cumulative thyroidal doses greater than his cumulative natural dose. Because of the relative absence of iodine–131 in the environment for the past 4 years, the children of today whose cumulative fallout exposure exceed their natural background exposure are those born in 1957 in Cincinnati, Salt Lake City and St. Louis. From the results obtained from these three out of five cities for which data are available, it is apparent that children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, and possibly in some other unmonitored areas of the United States, have cumulative thyroidal doses from iodine-131 following atmospheric weapons tests greater than their cumulative natural background doses, but less than the cumulative dose at an annual dose rate equal to the Radiation Protection Guide (RPG) during the same period.

This report estimates the cumulative thyroidal radiation dose to children born after 1957 from drinking fresh, whole milk containing iodine–131 from atmospheric weapons testing. Although iodine–131 was present in the environment as early as 1945, 1957 was selected for the study origin since it was the earliest year for which iodine–131 in milk was routinely measured.

Children were selected for this study since they are major consumers of fresh milk, their thyroid weights are the smallest, they are generally considered to be the most radiosensitive, and their total exposure history can be defined.

While the best method of estimating thyroidal exposures to various subpopulations is by the measurement of radioiodine in the thyroid, only limited data are available for either *in vivo* or *in vitro* studies (*1–3*). Consequently, an indirect method was used to calculate the iodine–131 dose to an average individual's thyroid via a one-compartment model. To do this, it is necessary to know the amount of iodine–131 ingested, the fraction that reaches the thyroid, and the weight of the thyroid gland (*4*). The first is the product of the concentration of

[1] Mr. Neill is deputy chief, Office of Criteria and Standards, Bureau of Radiological Health and Mr. Robinson was formerly staff officer, OCS, BRH, and is presently a member of the technical staff at the Bell Telephone Laboratories. Holmdel, N.J.

the radionuclide in the milk and the amount of milk consumed. It is assumed that the sole source of iodine–131 intake is fresh milk. Because the biological parameters listed above change rapidly at early ages, the method of calculation considered these parameters as functions of age.

Age-dependent thyroidal dose estimates using milk data were reported by Lewis as early as 1959 (*5*). In this report, the cumulative dose for an average child in 60 U.S. cities was obtained by a retrospective cohort approach developed by a Division of Radiological Health Committee in 1964.[2] Doses were estimated for each quarter year of a child's life in conjunction with the appropriate milk consumption rate, organ weight, and uptake factor for that particular age and the applicable concentrations of iodine–131 in milk at that time. The calculation was repeated using the appropriate concentration of idoine–131 in milk to be found in the following quarter year, together with the biological parameters associated with a child who is 3 months older. The quarterly doses, including the contribution from the second and third trimester of the gestation period, were then summed to obtain the cumulative dose.

Model

Although more sophisticated multicompartment models have been published in the past (*6–7*), a one-compartment model was selected since it has been used by the Federal Radiation Council (FRC) (*8–11*) and the International Commission on Radiological Protection (ICRP) (*4*).

The following assumptions were made:

(a) the sole source of iodine–131 results from the ingestion of fresh, whole cow's milk. The contribution from other foods was not evaluated due to the absence of routine measurements. Although Eisenbud (*12*) reported the presence of iodine–131 in the thyroid of a nonmilk-drinking individual in New York who consumed yogurt, and Bostrom (*13*) reported iodine–131 in lettuce in Utah following an atmospheric weapons test in Nevada, these foods are not considered to be major foodstuffs for children;

(b) the radioiodine is uniformly distributed in the thyroid;

(c) all beta-particle energy released in the thyroid is absorbed in the thyroid. Assuming a spherical shape for the thyroid, its radius at birth of 7 mm permits most of the energy of the beta particles whose range is 2 mm to be absorbed. This is less true for the fetal thyroid;

(d) the contribution by gamma photons amounts to about 10 percent of the total dose and is included by weighting the energy released per disintegration. Comparison with the Hine and Brownell expression for total dose (*6*) which considers the size of the thyroid for the gamma contribution, shows the dose in this paper to be 4 percent lower at birth and negligibly different at age 10;

(e) the disappearance rate from the thyroid is composed of the radioactive decay and biological elimination;

(f) no adjustments for sex, health, race, economic status, geographical or other epidemiological factors need to be made in the model;

(g) the relative biological effect (RBE) factor is equal to 1;

(h) milk samples obtained from the PHS Pasteurized Milk Network (PMN) and Raw Milk Network (RMN) are representative of the milk consumed at each of the stations;

(i) the uptake of iodine–131 is instantaneous;

(j) the biological half-life is constant and equal to 138 days (*4*). Since the effective half-life is equal to the product of the biological half-life and the physical half-life divided by their sum, a considerable variation in biological half life will not markedly affect the effective half life of 7.6 days for iodine–131 used in the calculation. For example, biological half-lives of 40 days and 300 days shift the effective half life (and calculated doses) by −12 percent and +0.3 percent, respectively.

Derivation of equations

The equation for thyroidal dose due to a continuous intake of P (μCi/day) during a quarter year may be developed as follows:

[2] Weiss, E. S., S. P. Abrahams, A. H. Wolff, R. H. Neill, A. Berger, G. Gaffney, and C. E. Nelson. Doses from iodine–131 found in radioactive fallout, unpublished committee report (1964).

For $0 \leq t \leq 90$ days

$$\frac{d(f_2q)}{dt} = P - \lambda(f_2q)$$

Now $f_2q = 0$ at $t = 0$
Therefore,

$$f_2q = \frac{P}{\lambda}(1 - e^{-\lambda t}) \qquad \cdots \quad (1)$$

For $t \geq 90$ days

$$\frac{d(f_2q)}{dt} = -\lambda(f_2q)$$

Now $f_2q = f_2q(90)$ at $t = 90$ days
Therefore,

$$f_2q = \frac{P}{\lambda}(e^{\lambda 90} - 1)e^{-\lambda t} \qquad \cdots \quad (2)$$

where

f_2q = amount of iodine–131 in thyroid at time t (μCi);
λ = effective decay constant (day^{-1});
P = rate of radioiodine intake to thyroid (μCi/day).

now

$$D = \int_0^\infty D_r\, dt \quad \text{and} \quad D_r = \frac{k}{m}(f_2q)$$

where

D = infinite dose from the exposure during a quarter (mrem);
D_r = dose rate (mrem/day);
k = proportionality constant
m = weight of thyroid (g)

The total dose can then be expressed as the sum of both contributions of equations (1) and (2) as

$$D = \frac{kP}{\lambda m}\int_0^{90}(1 - e^{-\lambda t})dt + \frac{kP}{\lambda m}(e^{\lambda 90} - 1)\int_{90}^\infty e^{-\lambda t}dt$$

$$D = \frac{kP}{\lambda m}$$

where $P = 10^{-9}\, M' s f_w$ (μCi/day)

$$k = \left(\frac{10^{-6}\ \text{Ci}}{\mu\text{Ci}}\right)\left(\frac{3.7 \times 10^{10}\ \text{dis}}{\text{sec-Ci}}\right)\left(\frac{0.22\ \text{MeV}}{\text{dis}}\right)$$

$$\times\left(\frac{1.6 \times 10^{-6}\ \text{erg}}{\text{MeV}}\right)\left(\frac{10^{-2}\ \text{rad-g}}{\text{erg}}\right)\left(\frac{1\ \text{rem}}{\text{rad}}\right)$$

$$\times\left(\frac{7.2 \times 10^{4}\ \text{sec}}{\text{day}}\right)\left(\frac{90\ \text{day}}{\text{quarter}}\right)\left(\frac{10^{3}\ \text{mrem}}{\text{rem}}\right)$$

$$= 11.25 \times 10^{6}\ \frac{\text{g-mrem}}{\mu\text{Ci-day}}\left(\frac{90\ \text{day}}{\text{quarter}}\right)$$

Substituting the appropriate values, one obtains

$$D = \frac{0.01125 M' s f_w}{m}$$

where

D = infinite dose from the exposure during a quarter (mrem)
M' = concentration of iodine–131 in milk (pCi/liter)
s = consumption of fresh milk (ml/day)
m = weight of thyroid (g)
f_w = fraction of ingested radioiodine reaching the thyroid.

The cumulative thyroidal dose [$D(T, \theta)$] is the sum of the quarterly doses received by a child. Since the consumption (s), uptake factor (f_w) and mass of the thyroid (m) vary with the age of the child at the beginning of the study (θ, quarter years) and the iodine concentration is a function of the time and location of the exposure, one can write

$$D(T, \theta) = \sum_{t=0}^{T} \frac{0.01125\ M'(t, \theta)s(t, \theta)f_w(t, \theta)}{m(t, \theta)}$$

Since D, M′, s, f_w and m are functions of age, the general form of the functions, $G(t, \theta)$, could have been written as $G(t+\theta)$.

where T = total length of study period (quarter years)
and t = time since study began quarter years).

The products of s, f_w and m^{-1} are shown in table 1. It is of interest to note that the last column identifies 6- to 11-month-old children as the subpopulation that receives the greatest dose for a given iodine–131 concentration in milk although knowledge of possible differential radiosensitivity of the age groups would have to be considered in evaluation of the final radiological health significance of these relative numbers.

Table 1. Estimates of average values of milk consumption, thyroid uptake of iodine-131 and thyroid weight for specified age groups

Age group	Milk consumption[a] (ml per day)	Iodine-131 thyroid uptake (fraction)	Thyroid weight (grams)	Consumption × uptake / Thyroid weight
	Average	Average	Average	Average
2nd trimester	[a]1,000	0.002	0.1	20.0
3rd trimester	[a]1,000	.016	.7	22.9
0–2 months	[b]100	.30	1.5	20.0
3–5 months	500	.30	1.8	83.3
6–11 months	700	.30	2.0	105.0
12–23 months	600	.30	2.3	78.3
24–35 months	700	.30	2.9	72.4
36–59 months	800	.30	3.9	61.5
5–9 years	800	.30	5.3	45.3
10–14 years	900	.30	9.6	28.1
15–19 years	1,000	.30	14.2	21.2
20–29 years	500	.30	15.6	9.61
30 years and over	400	.30	17.5	6.86

[a] At fetal ages, consumption figures are for mother.
[b] Average portion of total milk consumption that is received from fresh, whole cow's milk.

Fraction of iodine–131 reaching the thyroid

Uptake fractions by Evans (*14*) for the fetal thyroid are shown in table 1. Since the evidence (*14*) indicates that iodine–131 begins accumulating in the fetal thyroid at the beginning of the second trimester, the cumulative doses included this contribution. After birth, the uptake fraction was assumed to be 0.30 as reported by the Federal Radiation Council (*11*) and ICRP (*4*). Recent unpublished data[3] suggest that uptake fractions after birth are 0.20. While we have chosen to retain the published 0.30 figure in our calculations, the reader is advised that the results may be high by about 50 percent.

Mass of the thyroid gland

Prenatal thyroid weights shown in table 1 were those reported by Evans (*14*). Postnatal values were taken from Kay, et al (*15*). Both are similar to weights reported by Mochizuki (*16*) for thyroids obtained in New York City. For the purpose of the study, the mass of the thyroid was assumed to vary exclusively with age.

Eisenbud (*17*) and Beierwalters (*18*) have each reported fetal to maternal ratios of iodine–131 activity per gram of thyroid of 1.13 and 1.16, respectively. In the former case, the 5-month fetus (representative of the second trimester) and in the latter, full term (representative of the third trimester). Using an uptake fraction of 0.30 and thyroid weight of 15.6 g for the mother, the calculated uptake fractions are 0.0217 g and 0.0223 g, respectively. These compare quite well with those used in the calculations of 0.02 and 0.0228 fraction/g, respectively.

Concentrations of iodine–131 in milk

Monthly measurements of iodine–131 in milk were started in June 1957 at five Raw Milk Network stations (RMN). The network was expanded to 9 stations in August 1958. Weekly measurements of iodine–131 concentrations in pasteurized milk are available from most of the 63 stations comprising the Pasteurized Milk Network (PMN) from 1961 to the present. These data have been published each month in *Radiological Health Data and Reports.* Considering the results of Robinson (*19*), it was assumed that concentrations obtained by the two networks are interchangeable and that they both reflect iodine–131 in milk being consumed in these cities. While the PMN samples are composited to reflect the average milk being consumed in a given city, the RMN is composited somewhat differently.

Corrections were made for the decay of iodine–131 in milk by assuming a 2-day elapsed time between sample collection and consumption. The calculated doses were thus reduced by 17 percent. In rural areas where there may be a time lag of only 1 to 2 days from production to consumption, the calculated estimates could be increased by 30 percent.

Since there are no data on iodine–131 in milk prior to 1961 at 53 cities, the thyroidal estimates for children in those communities do not include any exposures prior to 1961. For example, the calculation of total cumulative dose to a child born in 1957 in Denver, Colo., does not include any exposures prior to 1961.

[3] Personal communication, Henry N. Wellman, January 24, 1967.

[4] Division of Radiological Health. A pilot study of the average daily intake of milk among small children in a selected area of the United States, unpublished report (December 1962).

Milk consumption

Consumption of fresh whole cow's milk for children [4] (*20*) are shown in table 1. The average annual consumption shown in table 1 for children up to the age of 15 is 820 ml/day. While this figure compares quite well with the average consumption of 800 ml/day reported in the National Consumer Beverage Survey for the winter of 1962 (*21*), the latter summarizes consumption for groups in 6-year increments which is not sufficiently detailed for this study.

Results

Unless otherwise specified, the term "dose" is always the cumulative radiation dose to the thyroid from iodine–131. All of the cumulative doses reported in this study are thyroidal doses received by the average milk-drinking member of the identified subpopulation. While no statement can be made from our calculations about the maximum dose received by any individual, the FRC suggests that no individual is likely to receive a dose greater than three times the average of a population (*9*).

Figure 1 shows the thyroid dose to children born since 1957 where there is a continuous record of measurements of iodine–131 in milk. At all cities, there are clear-cut maxima occurring for children born in 1957. This resulted from the atmospheric weapons tests conducted by the United States, the United Kingdom, and the Soviet Union during that year. While the cumulative doses for children born in January 1957 do not include dose incurred during their second and third trimester in utero exposure and first 6 months after birth, these doses are shown since they are the largest observed even without the previous 12-month exposure. A secondary peak occurred in 1961 which reflects foreign nuclear testing during that year. After the cessation of atmospheric weapons testing with the subsequent implementation of the limited test ban treaty, atmospheric iodine–131 virtually disappeared in the spring of 1963 except for a relatively small amount that has appeared since then. Although the curves are roughly parallel, one can note the considerable variation in the cumulative doses at different cities for a particular cohort (children born the same year). Among the 5 cities with iodine–131 concentration records dating back to 1957, the greatest doses of 1750 mrem and 1625 mrem were received by children born in 1957 in St. Louis and Salt Lake City, respectively. Figures 2 to 10 show the cumulative iodine–131 dose for children in 61 major cities born since 1957 by different geographical regions. The radiation dose estimates in all cases are given from the date of first data as indicated on the figures.

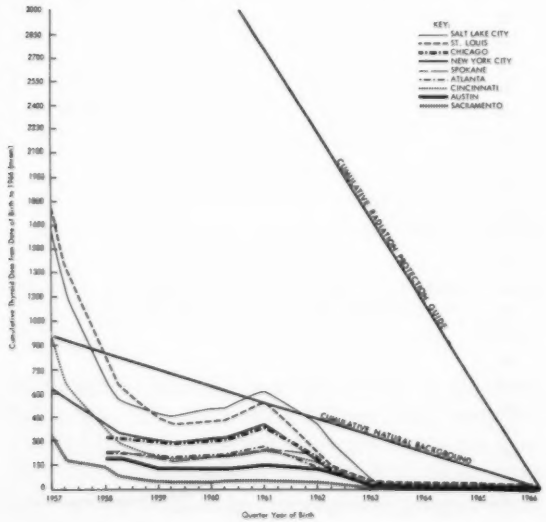

Figure 1. Total thyroid dose from iodine–131 in milk to children born since 1957, contrasted to the cumulative background dose and FRC guidelines

Comparison to natural background

There are a variety of ways in which the results may be compared to doses from natural background, which can yield a variety of conclusions. If one uses an annual natural background dose of 100 mrem (*9*) to individuals in the population, the following observations can be made.

By June 1966, a child born in January 1957 would have received 950 mrem cumulative natural background since birth (figure 1). Thus, children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, would have received man-made doses 1, 2, and 2 times the natural background, respectively, for these cities during these years. Children born in 1961 in St. Louis and Salt Lake City have received equally as much thyroidal exposure from man-made radiation as natural exposure during their first 5½ years of life through June 1966.

At the time that the limited test ban treaty was implemented in 1963, children born in 1957 had received 600 mrem natural exposure. The ratio of the man-made contribution to natural background for the average child born in 1957 in the following 5 cities for which data are available would then have been St. Louis, 3, Salt Lake City, 3, Cincinnati, 2, New York City, 1, and Sacramento, 0.6. If one assumes that the results for the 5 cities (for which 1957 data are available) are applicable to the entire United States, it means that in 1963 the average child of 6 years of age received man-made thyroidal doses from fallout greater than that which he had received from natural radioactivity up to that point in his life. No other known radionuclide from fallout has been found to produce radiation doses comparable to those received from natural background.

In certain years, some man-made doses were much larger than those received from natural background. This fact is indicated by the abrupt changes in slope in the curves in figures 1 to 10.

Applicable guidance

The Federal Radiation Council has established two types of guidelines for limiting radiation exposures to the general population. While

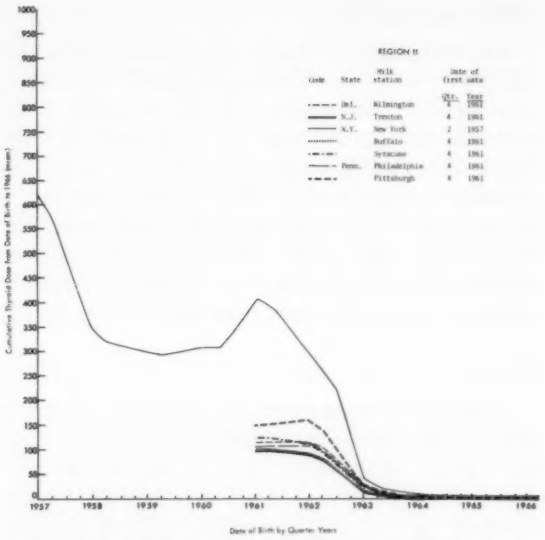
REGION II
Code State Milk station Date of first data
Qtr. Year
Del. Wilmington 4 1961
N.J. Trenton 4 1961
N.Y. New York 2 1957
Buffalo 4 1961
Syracuse 4 1961
Penn. Philadelphia 4 1961
Pittsburgh 4 1961
Cumulative Thyroid Dose from Date of Birth to 1966 (mrem)
1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
Date of Birth by Quarter Years

Figure 3. Cumulative iodine–131 dose for children born since 1957 in Region II, by quarter years

neither is particularly applicable for interpreting the doses calculated in this report, comparisons have been made in the belief that they provide a meaningful background for interpretation.

The first of these guidelines, termed Radiation Protection Guide (RPG) was published in May 1960 and is applicable to exposures resulting from controllable sources (*11*). A specific

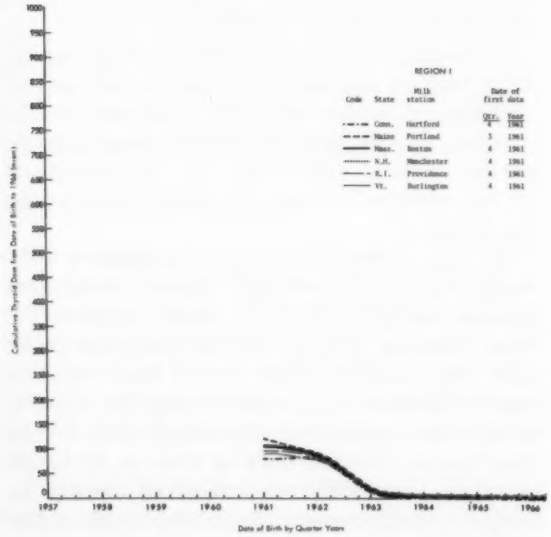
REGION I
Code State Milk station Date of first data
Qtr. Year
Conn. Hartford 4 1961
Maine Portland 3 1961
Mass. Boston 4 1961
N.H. Manchester 4 1961
R.I. Providence 4 1961
Vt. Burlington 4 1961
Cumulative Thyroid Dose from Date of Birth to 1966 (mrem)
1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
Date of Birth by Quarter Years

Figure 2. Cumulative iodine–131 dose for children born since 1957 in Region I, by quarter years

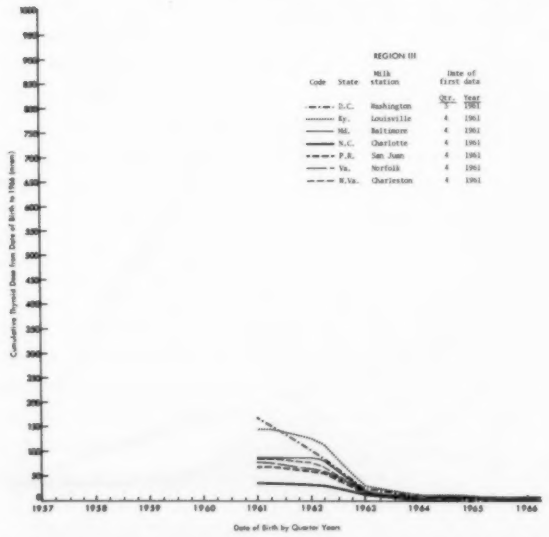
REGION III
Code State Milk station Date of first data
Qtr. Year
D.C. Washington 3 1961
Ky. Louisville 4 1961
Md. Baltimore 4 1961
N.C. Charlotte 4 1961
P.R. San Juan 4 1961
Va. Norfolk 4 1961
W.Va. Charleston 4 1961
Cumulative Thyroid Dose from Date of Birth to 1966 (mrem)
1957 1958 1959 1960 1961 1962 1963 1964 1965 1966
Date of Birth by Quarter Years

Figure 4. Cumulative iodine–131 dose for children born since 1957 in Region III, by quarter years

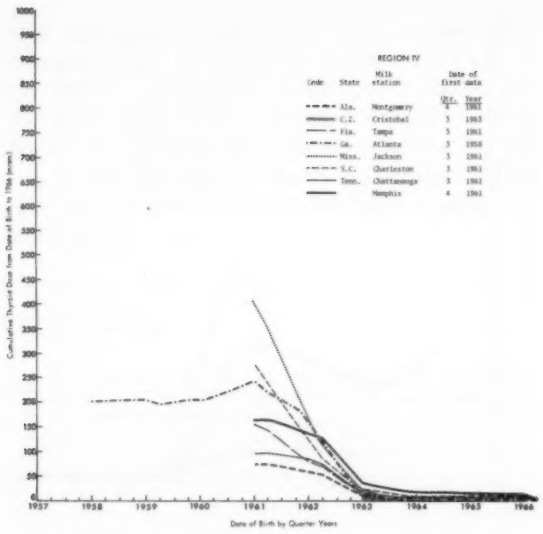

Figure 5. Cumulative iodine–131 dose for children born since 1957 in Region IV, by quarter years

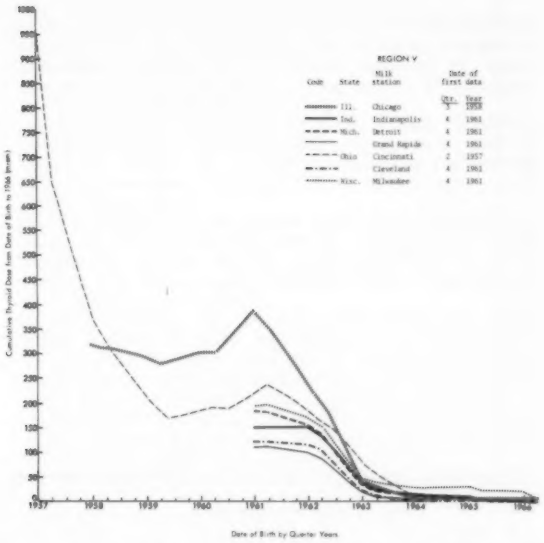

Figure 6. Cumulative iodine–131 dose for children born since 1957 in Region V, by quarter years

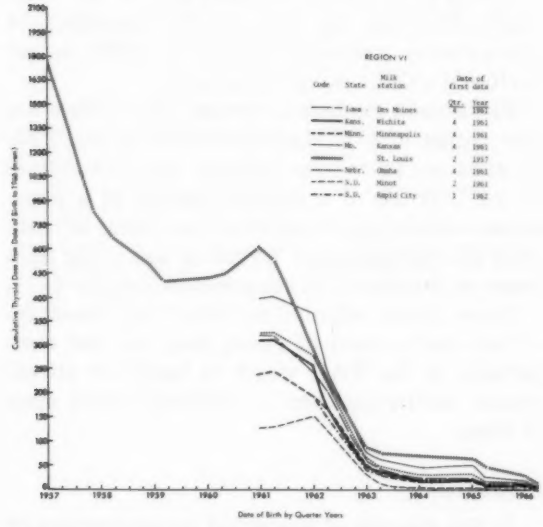
REGION VI
Code State
Milk station
Date of first data
Qtr. Year
Iowa Des Moines 4 1961
Kans. Wichita 4 1961
Minn. Minneapolis 4 1961
Mo. Kansas 4 1961
St. Louis 2 1957
Nebr. Omaha 4 1961
N.D. Minot 2 1961
S.D. Rapid City 3 1962
Cumulative Thyroid Dose from Date of Birth to 1966 (mrem)
Date of Birth by Quarter Years

Figure 7. Cumulative iodine–131 dose for children born since 1957 in Region VI, by quarter years

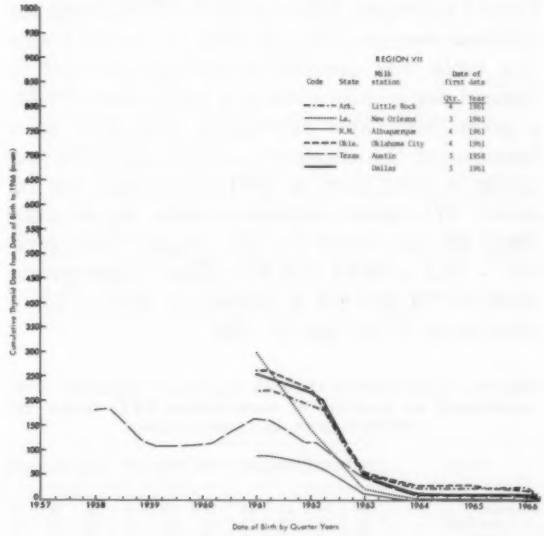
REGION VII
Code State
Milk station
Date of first data
Qtr. Year
Ark. Little Rock 4 1961
La. New Orleans 3 1961
N.M. Albuquerque 4 1961
Okla. Oklahoma City 4 1961
Texas Austin 3 1958
Dallas 3 1961
Cumulative Thyroid Dose from Date of Birth to 1966 (mrem)
Date of Birth by Quarter Years

Figure 8. Cumulative iodine–131 dose for children born since 1957 in Region VII, by quarter years

RPG for iodine–131 was published in September 1961 (*8*). Although fallout has been excluded from the category of controllable sources, the FRC subsequently indicated in May 1965 that the RPG could be compared to annual doses from fallout for an indication of need to initiate more careful evaluation of fallout exposures (*10*). Despite the fact that our tabulations of results were based on cumulative exposures and not annual increments, one can reasonably use cumulative exposures as a basis of comparison. The FRC recommended that the RPG for the thyroid gland be 500 mrem per year when applied to the average suitable samples of an exposed group in the general population (*8*).

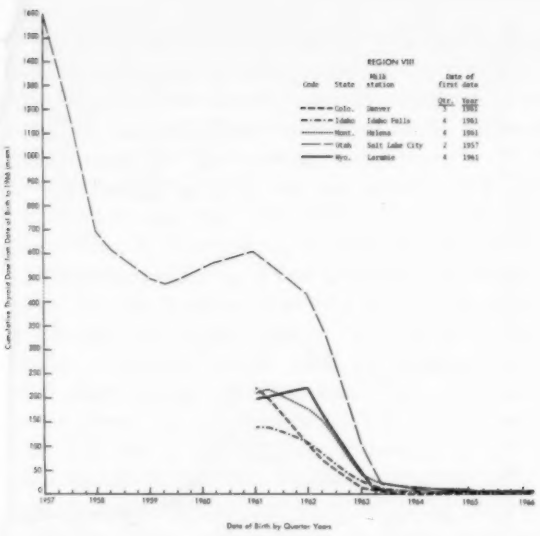

Figure 9. Cumulative iodine–131 dose for children born since 1957 in Region VIII, by quarter years

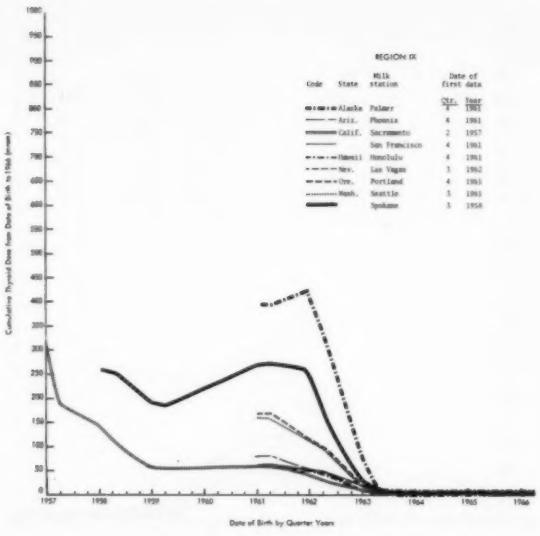

Figure 10. Cumulative iodine–131 dose for children born since 1957 in Region IX, by quarter years

Table 2 expresses the cumulative RPG doses for children born in different cities in various years. The table was derived by noting the dose in figure 1 for a child born in a particular city for a given year and expressing that dose as a fraction of the cumulative RPG dose. For example, a child born in 1961 in Chicago has received 375 mrem cumulative dose up to June 1966. He has lived for 5½ years. Therefore, $375 \div (5.5 \times 500) = 0.13$. The appropriate value of 13 percent is shown in table 2 for a child born in Chicago in 1961.

Table 2. Cumulative thyroid dose as of January 1967 expressed as percent of cumulative RPG doses for children born in various years

City	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
St. Louis	35	19	11	13	18	10	3	2	3	8
Salt Lake City	32	15	12	15	21	16	3	0	0	0
Cincinnati	19	8	5	6	8	7	1	0	0	0
Chicago	[a]—	7	7	9	13	8	1	0	0	0
New York City	13	9	8	9	14	7	1	0	0	0
Atlanta	—	5	5	6	9	6	1	0	1	4
Austin	—	4	4	4	5	6	1	0	0	0
Spokane	—	5	5	6	8	8	1	0	0	0
Sacramento	7	3	1	1	2	1	0	0	0	0

[a] Milk data begins in 1958.

Table 2 shows that the man-made cumulative thyroidal doses in January 1967 are less than the cumulative RPG doses. The subpopulation identified in the table with the largest fractions are children born in 1957; at St. Louis, 40 percent, and at Salt Lake City, 30 percent.

If one were to retrospectively view the man-made doses at the time of the cessation of atmospheric weapons testing in 1963, larger factional values would be noted.

The second guideline, termed a Protective Action Guide (PAG) was established by the FRC in 1964 as 10 mrems average projected doses to the thyroids of a suitable sample of a population which was considered to consist of children of approximately 1 year of age using milk from a reasonably homogeneous supply (*11*).

Since these calculations sum the doses received over a span of years, they are not comparable to the PAG which is based on an exposure occurring over a relatively short span of time.

Conclusions

In the absence of measured concentrations of iodine–131 in thyroids, it is believed that the approach of calculating thyroidal concentrations based on measurements of iodine–131 in milk is the best method available to identify and evaluate previous exposures to children; the subpopulation at greatest risk.

When data are available on the distributions of the model parameters as a function of age, time, location, sex, etc., it is recommended that the calculation of doses to subpopulations on a basis other than average doses. This will pro-

duce tabulations subject to more meaningful interpretations by identifying the variation of dose within a given subpopulation. If iodine–131 reappears in the environment, these calculations should be updated periodically. Similarly, the role of radioiodine in foods other than fresh milk for children needs to be more adequately determined.

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SECTION I. MILK AND FOOD

Milk Surveillance, September 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, sponsored by the Bureau of Radiological Health and the Bureau of Community Environment Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides occurring or formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent abundance of the element potassium (*2*) resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both of these elements in milk have

Figure 1. Milk sampling networks in the Western Hemisphere reported in *Radiological Health Data and Reports*

been measured extensively and are relatively constant. As a result of a study made of the PHS Pasteurized Milk Network (PMN) results for calcium content in milk for the period, May 1963–March 1966, an average value for the PMN and its 2-standard deviation, 1.16 ± 0.08 g/liter, was developed as an appropriate calcium content in milk for use in general radiological health calculations or discussions (*3*). As a result of a parallel study, an average value for the PMN, 1.51 ± 0.21 g/liter, for potassium content in milk was developed (*3*).

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131 and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20–30 percent (*5*).

Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy on the whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions will be reflected in the data presentation. While this may appear to complicate comparisons of data, current levels for strontium–90 and cesium–137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides,

particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

Also reflected in the data presentation will be whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional factors other than radioactivity counting variations such as sample preparation, counting errors not inherent in the minimum detectable activity, and chemical yield variations, it will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

However, those networks whose practical reporting levels were given as greater than those above will use their reported values, in order that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides would fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter
Iodine–131	4–10 pCi/liter for levels <100 pCi/liter; 6–10% for levels ≥ 100 pCi/liter
Cesium–137	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter
Barium–140	5–10 pCi/liter at levels <100 pCi/liter; 6–10% for levels ≥ 100 pCi/liter

For iodine–131, cesium–137, and barium–140, there is one exception for these precision error ranges: which is the 25 pCi/liter at levels <100 pCi/liter for Colorado. The larger Colorado variation at low levels is a result of the counting time and sample volume presently considered practical for evaluation of Colorado milk supplies. This is also reflected in the practical reporting level for that network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not

be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practical. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

For the purpose of evaluating population exposure, the daily intake of radionuclides by exposed population groups, averaged over a year, constitutes an appropriate criterion. However, in order to provide guidance to Federal agencies in developing appropriate control programs, the FRC described a graded approach involving three ranges of transient rates of daily intake as determined by surveillance, applicable to different degrees of action as follows:

Range I—periodic confirmatory surveillance as necessary,

Range II—quantitative surveillance and routine control,

Range III—evaluation and application of additional control measures, as necessary.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	1.5	0.5	[c] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[c] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[d]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are:
Strontium-89, strontium-90—general population
Iodine-131 —children 1 year of age
Cesium-137 —infants

[b] Based on an average intake of 1 liter of milk per day.

[c] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[d] The guides expressed here were not given in the FRC reports, but were calculated using appropropriate FRC recommendations.

benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

FRC reports 5 and 7 set forth PAG's for the thyroid, bone marrow, and whole body doses from ingestion of foods contaminated with radionuclides following an acute contaminating event. For the case of strontium–89, strontium–90, and cesium–137 contamination, the Council defined three categories of dietary pathways in which action may be required following an acute event. The one appropriate to the milk surveillance data is category I—transmission of radionuclides to man through the pasture-cow-milk pathway.

In the case of iodine–131 contamination, the maximum concentration of iodine–131 observed in milk, which may occur 2 to 4 days following an acute incident, can be used to project doses for comparison to the PAG for the thyroid. For strontium–89, strontium–90, and cesium–137, the total dose to the critical organ resulting from contributions of all three of these radionuclides must be considered to determine whether the projected dose will exceed the recommended PAG for the organ of interest (bone marrow or whole body).

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration (*10*). Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Format for data reporting

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationships between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level. This procedure is required in

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Concentration at maximum in milk for single nuclide that would result in PAG (pCi/liter)
Strontium–89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium–90	Bone marrow			[c] 51,000
Cesium–137	Whole body			[c] 720,000
Iodine–131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium–89 and cesium–137 is the same as dose in first year; total dose from strontium–90 is 5 times strontium–90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

order to have numerical monthly concentration estimates that reflect all samples with detectable radioactivity, particularly when average annual intakes are developed.

If the occasion arises when an influx of new contamination occurs, particularly in the case of iodine–131, where sampling frequencies increase and/or the range of radionuclide concentration values for a month are significantly wider than the normal steady-state conditions, a column will be added after the appropriate monthly average reflecting the maximum value for that month. It is the transient maximum value of radionuclide concentrations resulting from an acute contaminating event to which the maximum concentrations in table 2 (derived from the FRC protective guides) can be compared. However, any protective action based on these concentrations being reached will take place immediately on the observance of the high concentrations. Should such cases occur, a more complete discussion of the events would be required and will be provided.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131 and cesium–137 for September 1968 and the 12-month period, October 1967–September 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–140 data have been omitted from table 3, since levels at the great majority of the stations for September 1968 were below the respective practical reporting levels, with the exception of those in table 4.

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level of iodine–131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 26 pCi/liter in the United States for the month of September 1968. The maximum 12-month average was 21 pCi/liter (Little Rock, Ark., New Orleans, La.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium–137 monthly averages ranged from 0 to 205 pCi/liter in the United States for the month of September 1968 and the maximum 12-month average was 110 pCi/liter (Central Florida), representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 monthly averages were generally below practical reporting levels, with the following exceptions: Hartford, Conn. (PMN)—3 pCi/liter, 4 samples; Portland, Maine (PMN)—3 pCi/liter, 5 samples; and Nashville, Tenn. (State)—4 pCi/liter, 3 samples.

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Table 3. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	9	0	0	14(4)	14
Alaska:	Palmer[c]	P	4	6	0	0	13	13
Ariz:	Phoenix[c]	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	19	21	0(4)	0	18(4)	19
Calif:	Sacramento[c]	P	3	2	0(4)	0	0(4)	5
	San Francisco[c]	P	0	1	0(4)	0	3(4)	5
	Del Norte	P	26	17	0	0	25	20
	Fresno	P	3	0	0	0	0	5
	Humboldt	P	4	4	0	0	16	11
	Los Angeles	P	3	0	0	0	13	7
	Mendocino	P	3	2	0	0	11	5
	Sacramento	P	4	2	0	0	13	6
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	4	0	0	14	7
	Shasta	P	4	3	0	0	16	3
	Sonoma	P	3	2	0	0	12	7
Colo:	Denver[c]	P	6	4	0(4)	0	3(4)	6
	Western	R	d		e	e	e	e
	Northeastern	R	d		e(3)	4	e(3)	e
	Eastern	R	d		N8	e	N8	e
	Southeast	R	d		N8	e	N8	e
	South Central	R	d		N8	e	N8	e
Conn:	Hartford[c]	P	11	10	3(4)	0	11(4)	12
	Central	R	8	8	0(4)	0	7(4)	9
Del:	Wilmington[c]	P	9	11	0(4)	0	11(4)	9
D.C.:	Washington[c]	P	10	10	0(4)	0	0(4)	6
Fla:	Tampa[c]	P	7	8	0(4)	0	82(4)	67
	West	R	14	15	0	9	31	29
	North	R	13	16	0	10	44	46
	Northeast	R	6	9	0	6	72	87
	Central	R	11	10	0	12	99	110
	Tampa Bay area	R	10	6	0	0	92	75
	Southeast	R	10	9	0	3	205	103
Ga:	Atlanta	P	14	15	0(4)	0	22(4)	20
Hawaii:	Honolulu[c]	P	4	3	0	1	0	4
Idaho	Idaho Falls[c]	P	3	6	0(5)	0	7(5)	8
Ill:	Chicago[c]	P	8	9	0(5)	0	10(5)	10
Ind:	Indianapolis[c]	P	9	8	0(5)	0	7(5)	7
	Northeast	P	8	9	0	0	15	8
	Southeast	P	12	10	0	0	10	9
	Central	P	12	8	0	0	2(4)	9
	Southwest	P	6	10	0	0	15	12
	Northwest	P	8	11	0	0	9(4)	11
Iowa:	Des Moines[c]	P	6	7	0(4)	0	0(4)	7
	Iowa City	P	6	7	0	0	13	3
	Des Moines	P	8(5)	7	0(5)	0	10(5)	2
	Spencer	P	7	7	0	0	14	4
	Charles City	P	N8		N8		N8	
Kans:	Wichita[c]	P	5	8	0(5)	0	3(5)	5
Ky:	Louisville[c]	P	15	12	0(4)	0	1(4)	5
La:	New Orleans[c]	P	19	21	0(4)	0	20(4)	23
Maine:	Portland[c]	P	12	12	3(5)	0	24(5)	28
Md:	Baltimore[c]	P	9	10	0(4)	0	6(4)	6
Mass:	Boston[c]	P	11	13	0(4)	0	23(4)	25
Mich:	Detroit[c]	P	8	9	0(4)	0	14	11
	Grand Rapids[c]	P	11	11	0(5)	0	14(5)	14
	Bay City	P	N8	4	N8	0	N8	5
	Charlevoix	P	N8	5	N8	0	N8	7
	Detroit	P	4	5	e(4)	e	3(4)	5
	Grand Rapids	P	5(2)	5	e(5)	e	7(5)	7
	Lansing	P	5(2)	4	e(2)	e	0(2)	2
	Marquette	P	7	7	e(2)	e	25(2)	21
	Monroe	P	3	4	e(2)	e	0(2)	2
Minn:	Minneapolis[c]	P	11	11	0(5)	0	19(5)	13
	Bemidji	P	17	15	0	0	18	21
	Mankato	P	7	6	0	0	0	0
	Rochester	P	6	8	0	0	11	0
	Duluth	P	18	19	0	0	36	20
	Worthington	P	6	6	0	0	13	0
	Minneapolis	P	13	12	0	0	19	10
	Fergus Falls	P	12	10	0	0	0	0
	Little Falls	P	10	9	0	0	31	13
Miss:	Jackson[c]	P	16	17	0(4)	0	13(4)	14
Mo:	Kansas City[c]	P	8	8	0(4)	0	3(4)	5
	St. Louis[c]	P	9	9	0(4)	0	8(4)	8
Mont:	Helena	P	6	5	0(4)	0	17(4)	9
Nebr:	Omaha[c]	P	6	7	0(4)	0	1(4)	5
Nev:	Las Vegas[c]	P	0	1	0(4)	0	3(4)	4
N.H.:	Manchester[c]	P	14	14	0(4)	0	40(4)	36
N.J.:	Trenton[c]	P	8	10	0(4)	0	14(4)	11
N.Mex:	Albuquerque[c]	P	0	2	0(4)	0	3(4)	2

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium–90		Iodine–131		Cesium–137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	6	9	0(4)	0	7(4)	10
	New York City[c]	P	12	12	0(5)	0	14(5)	14
	Syracuse[c]	P	8	10	0(4)	0	8(4)	6
	Albany	P	0	7	0	0	NA	e
	Buffalo	P	NA	7	NA	0	NA	e
	Massena	P	12	10	NA	0	NA	25
	Newburg	P	12	10	NA	16	NA	e
	New York City	P	10	10	0	0	e	21
	Syracuse	P	6	7	NA	0	NA	e
N.C.:	Charlotte[c]	P	14	15	0(4)	1	4(4)	11
N.Dak:	Minot[c]	P	13	11	0(5)	0	16(5)	13
Ohio:	Cincinnati[c]	P	8	9	0(4)	0	6(4)	0
	Cleveland[c]	P	7	10	0(4)	0	12(4)	9
Okla:	Oklahoma City[c]	P	9	10	0(5)	0	3(5)	4
	Oklahoma City	P	NA	—	NA	—	NA	—
	Enid	P	NA	—	NA	—	NA	—
	Tulsa	P	NA	—	NA	—	NA	—
	Lawton	P	NA	—	NA	—	NA	—
	Ardmore	P	NA	—	NA	—	NA	—
Ore:	Portland[c]	P	10	7	0(4)	0	19(4)	15
	Baker	P	7	6	e	e	0	4
	Coos Bay	P	0	10	e	e	24	13
	Eugene	P	0	3	e	e	34	12
	Medford	P	0	3	e	e	24	11
	Portland composite	P	6	7	e	e	e(4)	9
	Portland local	P	5	6	e	e	18(4)	13
	Redmond	P	0	4	e	e	16	26
	Tillamook	R	NA	10	e	e	NA	4
Pa:	Philadelphia[c]	P	8	10	0(4)	0	7(4)	9
	Pittsburgh[c]	P	12	12	0(4)	0	9(4)	13
	Dauphin	P	10	8	0	0	38	18
	Erie	P	12	12	0	0	19	23
	Philadelphia	P	16	10	0	0	21	16
	Pittsburgh	P	13	12	0	0	19	16
R.I.:	Providence[c]	P	10	11	0(4)	0	19(4)	18
S.C.:	Charleston[c]	P	12	14	0(4)	0	26(4)	27
S.Dak:	Rapid City[c]	P	12	10	0(5)	0	14(5)	11
Tenn:	Chattanooga[c]	P	17	14	0(5)	0	13(5)	13
	Memphis[c]	P	11	11	0(3)	0	0(3)	5
	Chattanooga	P	12	13	0(5)	1	17(5)	18
	Clinton	P	10	13	0(3)	3	19	21
	Knoxville	P	9	12	0(3)	4	14(3)	15
	Nashville	P	8	8	4(3)	1	11	18
Tex:	Austin[c]	P	3	4	0(4)	0	0(4)	2
	Dallas[c]	P	9	8	0(5)	0	3(5)	5
	Amarillo	R	NA	5	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	4
	El Paso	R	NA	1	NA	0	NA	0
	Fort Worth	R	NA	6	NA	0	NA	0
	Harlingen	R	NA	1	NA	0	NA	0
	Houston	R	NA	11	NA	0	NA	8
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	3	NA	0	NA	0
	San Antonio	R	NA	3	NA	0	NA	0
	Texarkana	R	NA	11	NA	0	NA	10
	Uvalde	R	NA	1	NA	0	NA	0
	Wichita Falls	R	NA	9	NA	0	NA	0
Utah:	Salt Lake City[c]	P	10	6	0(4)	0	19(4)	12
Vt:	Burlington[c]	P	10	11	0(4)	0	4(4)	9
Va:	Norfolk[c]	P	10	11	0(4)	0	6(4)	9
Wash:	Seattle[c]	P	7	9	0(4)	0	28(4)	21
	Spokane[c]	P	5	7	0(4)	0	11(4)	11
	Benton County	R	0	0	0	0	18	3
	Deer Park	R	0	3	0	0	e	2
	Elma	R	6	4	0	0	22	20
	Franklin County	R	N8	0	N8	0	N8	e
	Moses Lake	R	0	1	0	0	e	e
	Pierce County	R	5	3	0	0	18	8
	Sandpoint, Idaho	R	3	7	0	0	25	22
	Skagit County	R	6	4	0	0	20	14
W.Va:	Charleston[c]	P	16	12	0(4)	0	3(4)	4
Wisc:	Milwaukee[c]	P	6	8	0(5)	0	7(5)	10
Wyo:	Laramie[c]	P	0	4	0(4)	0	1(4)	7
CANADA:								
Alberta:	Calgary	R	8	9	d		22	18
	Edmonton	R	10	8	d		28	22
British Columbia:	Vancouver	R	14	14	d		60	51
Manitoba:	Winnipeg	R	8	8	d		28	24
New Brunswick:	Frederickton	R	15	15	d		26	24

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)							
Newfoundland:							
St. Johns	R	27	21	d		38	41
Nova Scotia: Halifax	R	12	12	d		23	24
Ontario: Ft. William	R	19	16	d		42	29
Ottawa	R	7	9	d		22	19
Sault Ste. Marie	R	17	15	d		50	31
Toronto	R	5	5	d		15	15
Windsor	R	6	5	d		20	14
Quebec: Montreal	R	8	10	d		21	20
Quebec	R	10	13	d		30	28
Saskatchewan:							
Regina	R	8	8	d		20	15
Saskatoon	R	10	9	d		24	18
CENTRAL AND SOUTH AMERICA:							
Columbia: Bogota	P	3	1	0	0	0	2
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	2
Jamaica: Montego Bay	P	9	5	0	0	245	125
Venezuela Caracas	P	3	1	0	0	0	0
Canal Zone: Cristobal[c]	P	3	1	0(4)	1	18(4)	9
Puerto Rico: San Juan[c]	P	5	5	0(4)	0	7(4)	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter; Washington—15 pCi/liter

Strontium-90: New York—3 pCi/liter

NA, no analysis.
NS, no sample collected.

Table 4. Reported concentrations of strontium-89 and barium-140 in milk

Strontium-89		Barium-140	
Sampling location	Monthly average (pCi/liter)	Sampling location	Monthly average (pCi/liter)
Idaho: Idaho Falls (PMN)	6	Calif: Del Norte (State)	14
Tenn: Clinton (State)	15	Humboldt	14
Knoxville	10	Mendocino	12
Canal Zone:		Fla:	
Cristobal (PMN)	20	North (State)	18
Columbia:		Central	26
Bogata (PAHO)	15	Southeast	21
Chile:		Maine:	
Santiago (PAHO)	20	Portland (PMN)	3(5)[a]
Ecuador:		Mo:	
Guayaquil (PAHO)	15	Kansas City (PMN)	3(4)
Jamaico: Montego Bay (PAHO)	15	St. Louis	3(4)
		Nev: Las Vegas (PMN)	3(4)
		S. Dak: Rapid City (PMN)	3(5)

[a] Number in parentheses indicates number of samples.

(5) KAUFFMAN, P., and F. KNOWLES. Interlaboratory study of iodine–131, cesium–137 and strontium–90 measurements in milk, March–April 1967.
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service raw milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rap 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
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Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

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Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

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Division of Occupational Health
Environmental Health Services
Texas State Department of Health

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Division of Technical Services
Washington State Department of Health

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provides a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	January–June 1968	November 1968
Tri-City Diet, HASL	April–December 1967	June 1968

1. Radionuclides in Institutional Diet Samples April-June 1968

Bureau of Community Environment Management

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Community Environment Management (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions, and 8 auxiliary institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1–2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

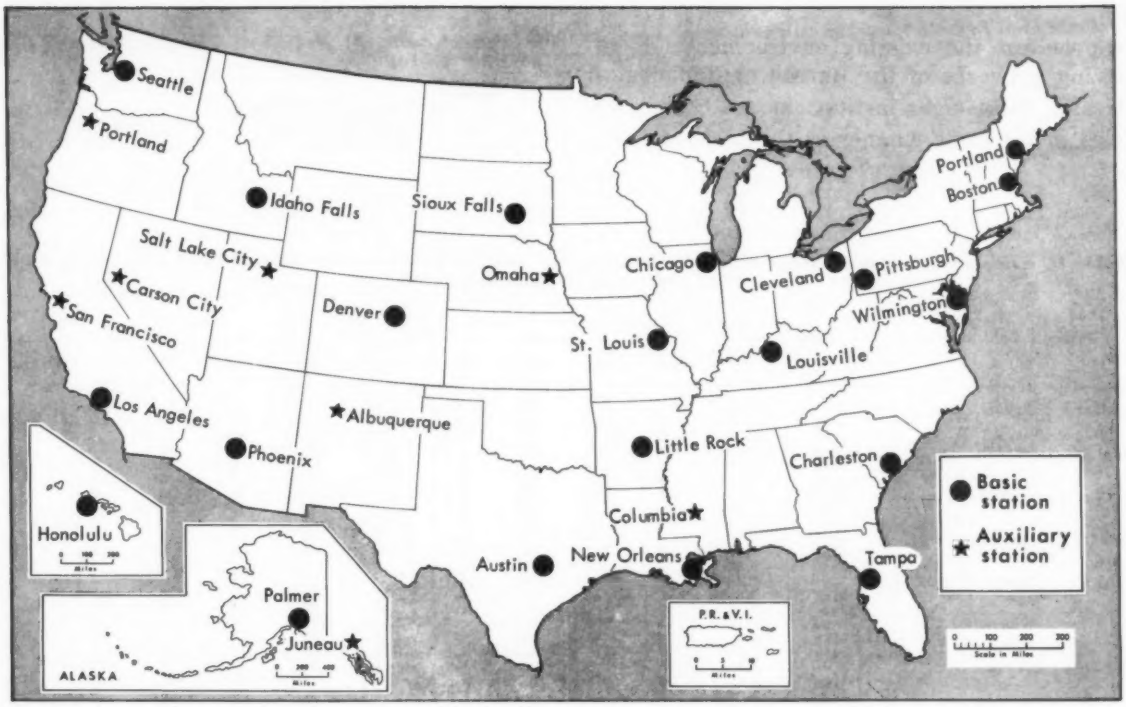

Figure 1. Instiutional diet sampling locations as of June 1968

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1968, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.80 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium–90 dietary intake during this period averaged 15 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*4*). Cesium–137 intakes averaged 24 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium–89	5 pCi/kg
Strontium–90	2 pCi/kg
Iodine–131	10 pCi/kg
Cesium–137	10 pCi/kg
Barium–140	10 pCi/kg
Radium–226	0.1 pCi/kg

Data from eight auxiliary stations is included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to

supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967 and annual Summary 1967	July 1968
January–March 1968	October 1968

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9–12 years of age), April–June 1968

Location of Institution		Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Palmer	April	1.56	0.5	0.7	1.2	1.9	9	13	16	25	0.4	0.6
		May	1.53	.7	1.0	1.5	2.2	NA	NA	20	31	.7	1.1
		June	1.94	.4	.8	1.2	2.3	8	16	16	31	.4	.8
Aria:	Phoenix	April	2.00	NA	NA	1.2	2.4	NA	NA	13	26	.5	1.0
		May	2.01	.5	1.0	1.3	2.5	NA	NA	0	0	.4	.8
		June	1.99	.6	1.1	1.7	3.4	5	9	0	0	.7	1.4
Ark:	Little Rock	April	1.77	.6	1.0	1.6	2.8	9	16	14	25	.6	1.1
		May	1.80	.6	1.1	1.8	3.2	15	27	19	34	.5	.9
		June	1.85	.5	.9	1.4	2.5	10	19	0	0	.4	.7
Calif:	Los Angeles	April	1.70	.5	.8	1.2	2.0	5	8	0	0	.7	1.2
		May	1.74	.7	1.3	1.1	1.9	NA	NA	0	0	.5	.9
		June	1.50	.5	.8	1.2	1.7	3	5	0	0	.4	.6
Colo:	Denver	April	2.40	.7	1.8	1.6	3.7	8	19	0	0	.6	1.4
		May[a]	2.34	.6	1.3	1.3	3.0	NA	NA	0	0	.3	.7
		June[a]	2.46	.7	1.7	1.2	3.0	5	12	0	0	.5	1.2
Del:	Wilmington	April	2.22	.7	1.5	1.5	3.2	7	15	14	31	.7	1.6
		May	2.26	.7	1.6	1.6	3.7	8	18	11	25	.9	2.0
		June	2.05	.7	1.5	1.5	3.1	9	18	14	29	.8	1.6
Fla:	Tampa	April	2.20	.5	1.2	1.8	3.9	6	13	28	62	.6	1.3
		May	2.23	.6	1.4	1.7	3.8	8	18	40	89	.7	1.6
		June	2.02	.6	1.2	1.8	3.6	7	14	24	48	.5	1.0
Hawaii:	Honolulu	April	2.27	.4	1.0	1.4	3.3	3	6	15	34	.4	.9
		May	2.25	.5	1.1	1.3	2.9	3	7	0	0	.6	1.4
		June	2.32	.5	1.1	1.3	2.9	7	16	15	35	.4	.9
Idaho:	Idaho Falls	April[a]	2.17	1.3	2.9	1.4	3.0	12	26	13	28	.2	.4
		May[a]	2.06	.7	1.5	1.6	3.3	8	15	13	27	.5	1.0
		June[a]	2.12	.9	1.8	1.6	3.4	8	18	19	40	.5	1.1
Ill:	Chicago	April[a]	1.25	.8	1.0	1.7	2.1	7	9	15	19	.6	.8
		May	1.56	.7	1.1	1.5	2.3	6	10	14	22	.8	1.2
		June	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ky:	Louisville	April	1.11	.5	.6	1.6	1.8	9	10	0	0	.9	1.0
		May	1.00	.4	.4	1.7	1.7	8	8	0	0	1.0	1.0
		June	.55	.4	.2	1.4	.8	13	7	0	0	1.2	.7
La:	New Orleans	April	1.61	.7	1.0	1.7	2.7	16	25	18	29	.5	.8
		May	1.87	.6	1.0	1.7	3.1	13	24	14	26	.5	.9
		June	1.65	.6	1.0	1.5	2.5	11	18	12	20	.6	1.0
Maine:	Portland	April	1.83	.8	1.4	1.6	2.9	10	19	20	37	.6	1.1
		May	1.61	.9	1.4	1.3	2.2	16	26	39	63	.8	1.3
		June	1.59	1.0	1.5	1.6	2.5	15	24	30	48	.9	1.4
Mass:	Boston	April	1.46	.8	1.1	1.7	2.4	9	13	19	28	.6	.9
		May	1.65	.7	1.2	1.4	2.4	8	14	13	21	.8	1.3
		June	1.56	.8	1.2	1.4	2.2	9	14	25	39	.7	1.1
Mo:	St. Louis	April	2.61	.8	2.2	1.6	4.0	14	37	0	0	.9	2.3
		May	2.65	1.0	2.6	1.6	4.2	9	23	12	32	.8	2.1
		June[a]	2.19	1.0	2.2	1.4	3.0	12	26	23	50	.9	2.0
Ohio:	Cleveland	April	1.55	.7	1.1	1.6	2.4	8	12	19	29	.3	.5
		May	1.38	.8	1.1	1.6	2.1	8	11	19	26	.7	1.0
		June	1.19	.6	.7	1.6	1.9	4	5	16	19	.5	.6
Pa:	Pittsburgh	April	2.19	.6	1.3	1.5	3.3	8	18	15	33	.6	1.3
		May	2.28	.6	1.3	1.6	3.7	8	18	14	32	.8	1.8
		June	2.13	.6	1.2	1.5	3.1	8	17	25	53	.8	1.7
S.C.:	Charleston	April	1.27	.7	.9	1.5	1.9	9	12	14	18	.5	.6
		May	1.72	.8	1.3	1.7	2.9	10	16	22	38	.8	1.4
		June	1.16	.6	.7	1.5	1.7	9	10	18	21	.6	.7
S.Dak:	Sioux Falls	April	1.33	.7	.9	1.2	1.6	6	8	0	0	.8	1.1
		May[a]	1.66	1.0	1.7	1.5	2.4	12	20	36	60	1.7	2.8
		June[a]	1.31	.6	.7	1.5	2.0	5	7	0	0	.6	.8
Tex:	Austin	April	1.93	.7	1.4	1.6	3.1	4	8	0	0	.4	.8
		May	2.08	.8	1.6	1.7	3.5	5	11	12	25	.5	1.0
		June	1.81	.7	1.3	1.5	2.7	4	8	0	0	.7	1.3
Wash:	Seattle	April	1.87	.6	1.0	1.6	2.9	5	10	16	30	.3	.6
		May[a]	1.98	.8	1.5	1.5	2.9	NA	NA	18	36	.7	1.4
		June[a]	1.89	.7	1.4	1.5	2.8	10	20	15	28	.7	1.3
Institutional average		April	1.84	0.6	1.2	1.5	2.7	8	15	12	21	0.6	1.1
		May	1.86	0.7	1.3	1.5	2.8	9	17	15	27	0.7	1.3
		June	1.69	0.6	1.0	1.5	2.5	8	13	13	23	0.6	1.0

[a] Since food samples were collected from two or more children who were not between the ages of 9–12, data for this month were not used in institutional average.

NS, no sample.

NA, no analysis.

Note: Since iodine–131, barium–140 and strontium–89 were not detectable at most stations during the second quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: iodine–131 was reported in April for Ohio, 13 pCi/kg; barium–140 was reported in April for Ohio, 15 pCi/kg; and also reported in June for Delaware, 17 pCi/kg.

Table 2. Concentrations and intake of stable elements and radionuclides in Institutional total diets of individuals (auxiliary stations) April–June 1968

Location of Institution		Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Juneau	April	1.51	0.4	0.5	1.2	1.8	5	8	0	0	0.3	0.5
		May	1.48	.6	.9	1.7	2.5	NA	NA	19	28	.4	.6
		June	1.27	.4	.5	1.8	2.3	5	6	15	19	.3	.4
Calif:	San Francisco	April	1.89	.7	1.2	1.7	3.1	4	8	21	40	1.1	2.1
		May	2.25	1.1	2.5	1.5	3.4	NA	NA	0	0	.6	1.4
		June	2.03	.7	1.5	1.5	3.1	7	13	0	0	.6	1.2
Miss:	Columbia	April	2.64	.9	2.4	1.4	3.7	13	34	0	0	.6	1.6
		May	2.11	.8	1.7	1.4	3.0	11	22	19	40	.5	1.1
		June	1.72	.7	1.2	1.4	2.4	16	28	13	22	.5	.9
Nebr:	Omaha	April	2.08	.9	1.9	1.6	3.2	6	13	0	0	.6	1.2
		May	2.04	1.2	2.5	1.7	3.5	8	16	0	0	1.3	2.7
		June	2.04	.8	1.7	1.4	2.9	6	12	12	24	.7	1.4
Nev:	Carson City	April	1.79	NA	NA	1.3	2.4	NA	NA	13	23	.7	1.3
		May	1.40	.7	1.0	2.1	2.9	NA	NA	11	15	.6	.8
		June	1.32	.7	.9	1.9	2.5	4	5	11	15	.6	.8
N. Mex:	Albuquerque	April	2.22	.6	1.3	1.5	3.3	4	9	0	0	.4	.9
		May	2.23	.6	1.4	1.6	3.7	5	11	0	0	.5	1.1
		June	1.31	.6	.8	1.6	2.1	6	8	0	0	.6	.8
Ore:	Portland	April	2.22	.6	1.3	1.6	3.6	6	13	20	44	.4	.9
		May	2.33	.6	1.3	1.6	3.8	NA	NA	14	33	.4	.9
		June	2.31	.6	1.4	1.6	3.7	6	14	23	53	.4	.9
Utah:	Salt Lake City	April	1.97	.5	.9	1.0	2.0	5	11	11	22	.3	.6
		May	1.70	.8	1.4	1.4	2.4	NA	NA	0	0	.6	1.0
		June	2.26	.6	1.4	1.2	2.7	5	11	12	27	.4	.9
Institutional average		April	2.04	0.7	1.4	1.4	2.9	6	14	8	16	0.6	1.1
		May	1.94	0.8	1.6	1.6	3.2	8	16	8	15	0.6	1.2
		June	1.78	0.6	1.2	1.6	2.7	7	12	11	20	0.5	0.9

NA, no analysis.
Note: Since iodine–131, barium–140 and strontium–89 were not detected at most stations during the second quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: strontium–89 was reported in April for California, 7 pCi/kg and Oregon, 10 pCi/kg.

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(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standard, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Colorado River Basin	1967	December 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, HASL	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Gross Radioactivity in Surface Waters of the United States, July 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveil-

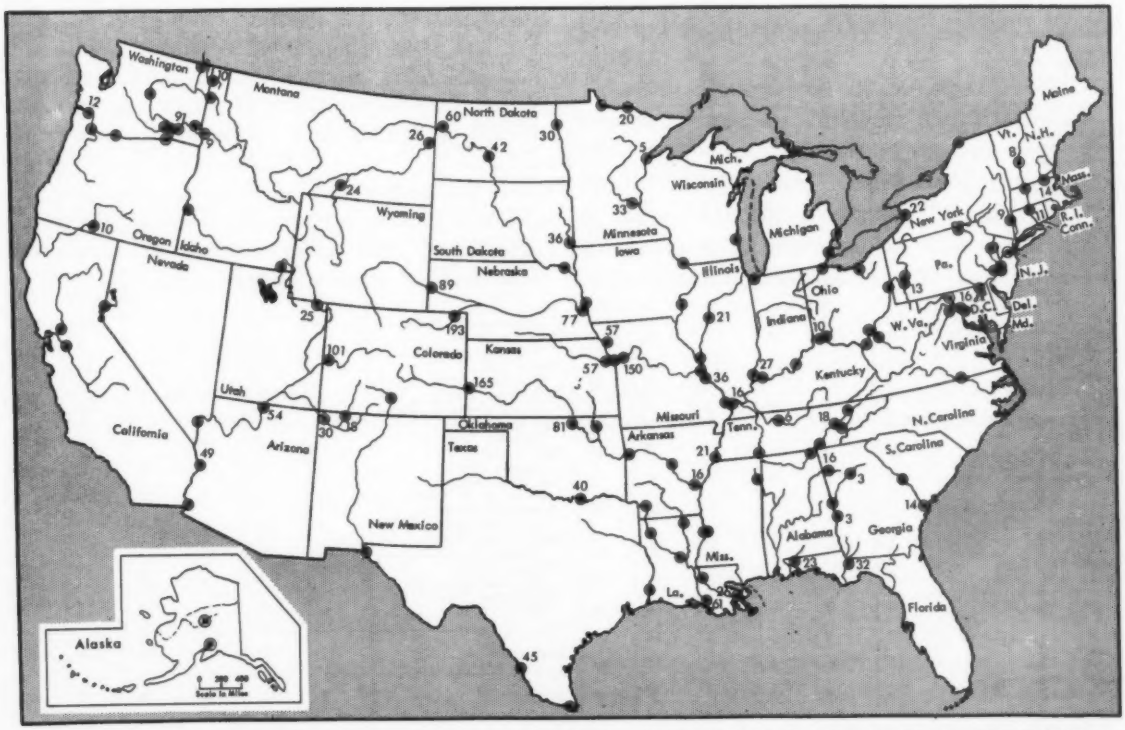

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, July 1968

lance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During July 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids: Arkansas River, Coolidge, Kans.; North Platte River, Henry, Nebr.; South Platte River, Julesburg, Colo. Julesburg, Colo., on the South Platte River showed beta radioactivity for dissolved solids in excess of 150 pCi/liter. No reason for this relatively high level is apparent, however, if river flows were unusually low, this level of radioactivity may be produced. The beta dissolved radioactivity on the Columbia River at Pasco, Wash., is considerably below 150 pCi/liter. This may be due to decreased reactor operations.

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.
(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, July 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	0	2	2	1	17	18
Apalachicola River:						
Chattahoochee, Fla.	1	0	1	2	30	32
Arkansas River:						
Coolidge, Kans.	21	38	59	58	107	165
Ponca City, Okla.	10	2	12	34	47	81
Pendleton Ferry, Ark.	0	0	0	1	15	16
Atchafalaya River:						
Morgan City, La.	13	1	14	46	15	61
Big Horn River:						
Hardin, Mont.	0	3	3	6	18	24
Big Sioux River:						
Sioux Falls, S. Dak.	1	3	4	5	31	36
Chattahoochee River:						
Atlanta, Ga.	0	0	0	1	2	3
Columbus, Ga.	0	0	0	0	3	3
Clearwater River:						
Lewiston, Idaho	0	0	0	2	7	9
Clinch River:						
Kingston, Tenn.[a]	0	<1	<1	2	16	18
Colorado River:						
Loma, Colo.	6	8	14	42	59	101
Page, Ariz.	0	5	5	3	51	54
Parker Dam, Calif-Ariz.	0	13	13	1	48	49
Columbia River:						
Pasco, Wash.[a]	<1	<1	<1	37	54	91
Clatskanie, Ore.	0	1	1	1	11	12
Connecticut River:						
Wilder, Vt.	1	0	1	2	6	8
Enfield Dam, Conn.	0	0	0	1	10	11
Coosa River:						
Rome, Ga.	<1	0	<1	6	10	16
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	0	6	6
Escambia River:						
Century, Fla.	1	1	2	5	18	23
Great Lakes:						
Duluth, Minn.	0	0	0	1	4	5
Buffalo, N.Y.	0	1	1	2	20	22
Green River:						
Dutch John, Utah	0	4	4	1	24	25
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	1	8	9
Illinois River:						
Peoria, Ill.	2	2	4	3	18	21
Kansas River:						
DeSoto, Kans.	2	2	4	20	37	57
Klamath River:						
Keno, Ore.	0	0	0	2	8	10
Merrimack River:						
Lowell, Mass.	0	0	0	8	6	14
Mississippi River:						
St. Paul, Minn.	1	2	3	6	27	33
E. St. Louis, Ill.	6	2	8	17	19	36
W. Memphis, Ark.	1	1	2	8	13	21
New Orleans, La.	3	3	6	8	18	26
Missouri River:						
Williston, N. Dak.	5	1	6	37	23	60
Bismarck, N. Dak.	1	5	6	7	35	42
St. Joseph, Mo.	4	2	6	31	26	57
Missouri City, Mo.	12	3	15	116	34	150
Monongahela River:						
Pittsburgh, Pa.	0	0	0	3	10	13
North Platte River:						
Henry, Nebr.	3	26	29	15	74	89
Ohio River:						
Cincinnati, Ohio	0	1	1	2	8	10
Cairo, Ill.	0	1	1	1	15	16
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	2	8	10
Platte River:						
Plattsmouth, Nebr.	10	4	14	44	33	77
Potomac River:						
Washington, D.C.	0	0	0	5	11	16
Rainy River:						
Baudette, Minn.	1	1	2	3	17	20
Red River, North:						
Grand Forks, N. Dak.	1	1	2	5	25	30
Red River, South						
Denison, Tex.	1	2	3	3	37	40
Rio Grande:						
Laredo, Tex.	5	3	8	20	25	45
San Juan River:						
Shiprock, N. Mex.	3	3	6	7	23	30
Savannah River:						
Port Wentworth, Ga.[a]	1	<1	1	3	11	14
South Platte River:						
Julesburg, Colo.	8	54	62	35	158	193
Wabash River:						
New Harmony, Ind.	1	1	2	10	17	27
Yellowstone River:						
Sidney, Mont.	4	2	6	13	13	26
Maximum	21	54	62	116	158	193
Minimum	0	0	0	0	2	3

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968

1. Radiation Alert Network
September 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number or samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	7	0	4	Sept 68	1	40	1	40	0
Alaska:	Adak	28	3	1	2	Apr 68	(c)				
	Anchorage	14	0	0	0	Oct 68	(c)				
	Attu Island	(b)				May 68	(c)				
	Fairbanks	1	2	2	2	Nov 68	(c)				
	Juneau	7	0	0	0	Dec 68	19	406	19	406	0
	Kodiak	20	2	0	0	Jan 69	(c)				
	Nome	(b)				July 68	(c)				
	Point Barrow	10	2	0	1	June 68	(c)				
	St. Paul Island	30	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	19	10	2	6	Dec 68	(c)				
Ark:	Little Rock	6	4	1	2	Oct 68	2	106	2	106	0
Calif:	Berkeley	19	1	0	0	Jan 69	(c)				
	Los Angeles	(b)				July 68	(c)				
C.Z:	Ancon	15	0	0	0	Jan 69	(c)				
Colo:	Denver	17	7	1	4	Jan 69	(c)				
Conn:	Hartford	19	0	0	0	Nov 68	4	43	4	43	3
Del:	Dover	19	1	0	1	Sept 68	(c)				
D.C.:	Washington	9	3	0	1	June 68	(c)				
Fla:	Jacksonville	20	2	0	1	Oct 68	6	48	6	48	44
	Miami	21	1	0	0	Nov 68	12	174	10	170	0
Ga:	Atlanta	19	2	1	1	Aug 68	2	32	2	32	20
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	29	1	0	1	May 68	1	10	0	0	(c)
Idaho:	Boise	20	7	1	4	May 68	1	7	1	7	0
Ill:	Springfield	7	5	0	1	June 68	3	8	0	0	(c)
Ind:	Indianapolis	19	8	0	2	Aug 68	5	24	5	24	38
Iowa:	Iowa City	16	3	0	1	Jan 69	9	84	9	84	0
Kans:	Topeka	20	4	0	2	Oct 68	7	78	7	78	4
Ky:	Frankfort	19	4	0	2	June 68	7	41	7	41	34
La:	New Orleans	18	7	0	1	June 68	5	41	0	0	(c)
Maine:	Augusta	19	2	0	1	Dec 68	5	39	5	39	0
Md:	Baltimore	19	2	0	1	Nov 68	3	18	3	18	2
	Rockville	14	3	0	1	May 68	(c)				
Mass:	Lawrence	19	2	0	1	Sept 68	4	38	4	38	33
	Winchester	15	4	0	1	Apr 68	5	36	5	36	0
Mich:	Lansing	19	3	1	2	May 68	9	79	9	79	270
Minn:	Minneapolis	21	5	0	0	Sept 68	8	122	8	122	189
Miss:	Jackson	19	9	0	1	Dec 68	3	49	3	49	45
Mo:	Jefferson City	19	4	0	1	Aug 68	8	133	8	133	0
Mont:	Helena	20	9	1	3	Apr 68	7	7	7	7	19
Nebr:	Lincoln	19	4	0	2	Aug 68	7	159	6	158	22
Nev:	Las Vegas	18	5	1	3	Nov 68	(c)				
N.H.:	Concord	19	3	1	1	June 68	(c)				
N.J:	Trenton	17	3	0	2	Dec 68	1	11	1	11	13
N. Mex:	Santa Fe	18	2	0	1	Apr 68	2	17	2	17	0
N.Y:	Albany	19	7	0	2	Aug 68	5	42	5	42	54
	Buffalo	20	1	0	1	Jan 69	(c)				
	New York City	20	2	0	1	Apr 68	(c)				
N.C:	Gastonia	15	12	2	6	Jan 69	3	83	(d)		
N. Dak:	Bismarck	18	4	0	2	June 68	5	38	4	18	15
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	16	4	0	2	Dec 68	7	71	0	0	(c)
	Painesville	20	2	0	1	Nov 68	9	37	9	37	0
Okla:	Oklahoma City	18	3	0	1	May 68	5	82	5	82	0
	Ponca City	21	6	1	3	Nov 68	2	76	2	76	0
Ore:	Portland	12	1	0	0	Aug 68	6	32	6	32	0
Pa:	Harrisburg	16	3	0	1	Aug 68	(c)				
P.R:	San Juan	(b)				Dec 68	(c)				
R.I:	Providence	17	6	0	1	May 68	2	40	2	40	10
S.C:	Columbia	18	3	0	1	Apr 68	3	35	3	35	5
S. Dak:	Pierre	10	8	1	5	Dec 68	(c)				
Tenn:	Nashville	15	3	0	1	May 68	7	55	7	55	6
Tex:	Austin	7	5	0	3	Sept 68	3	65	(d)		
	El Paso	19	6	1	3	June 68	(c)				
Utah:	Salt Lake City	30	3	0	1	July 68	1	10	1	10	6
Vt:	Barre	15	3	0	2	Oct 68	4	51	4	51	2
Va:	Richmond	15	1	0	0	Oct 68	2	32	2	32	22
Wash:	Seattle	22	0	0	0	Oct 68	7	33	(d)		
	Spokane	20	3	0	2	Sept 68	2	8	2	8	3
W. Va:	Charleston	17	2	0	1	Apr 68	6	52	5	44	8
Wisc:	Madison	19	1	0	1	Oct 68	10	182	10	182	85
Wyo:	Cheyenne	20	7	1	4	Nov 68	1	2	1	2	11
	Network summary	1,175	12	0	2		5	62	5	63	24

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

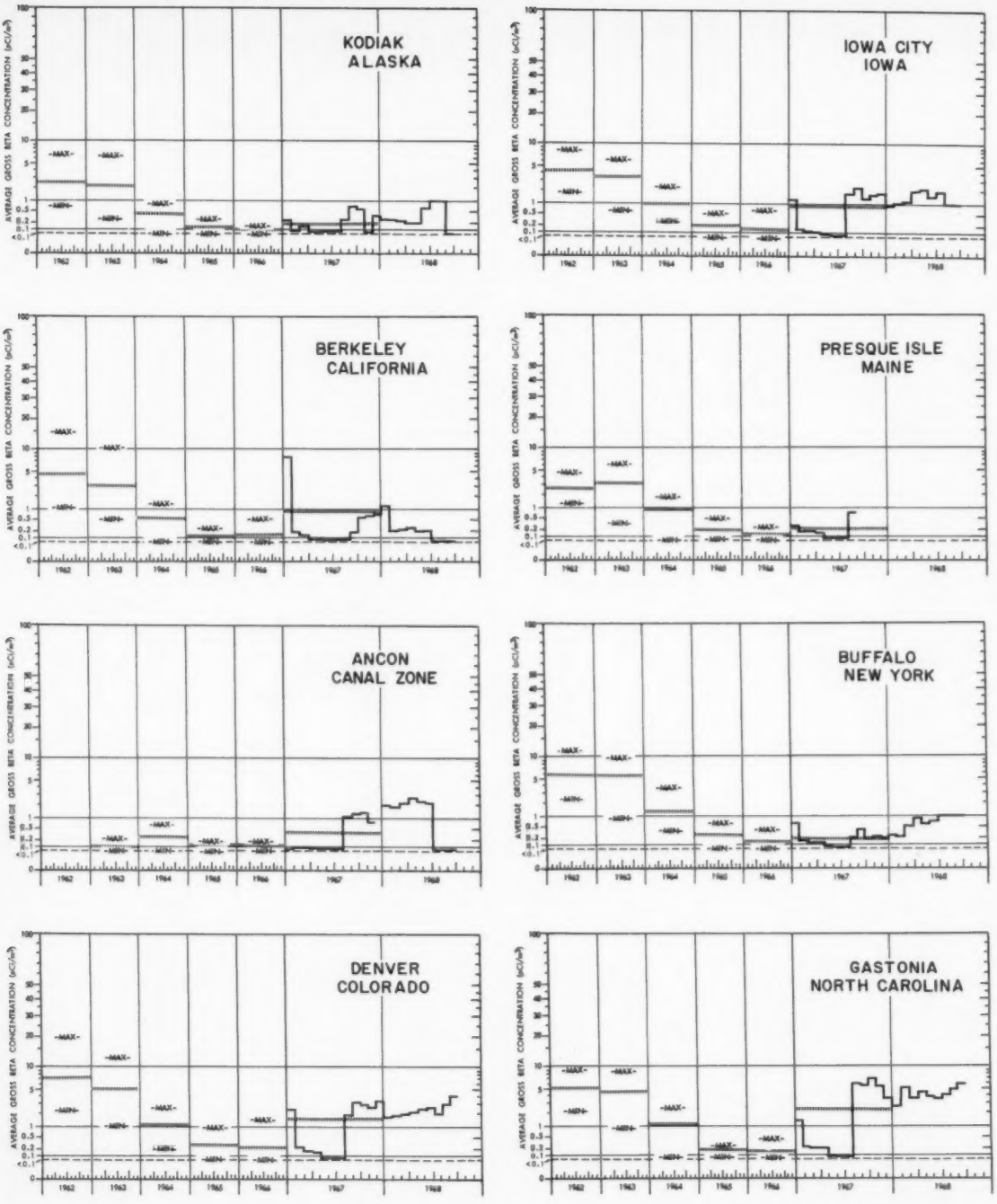

Figure 2. Monthly and yearly profiles of beta radioactivity in air — Radiation Alert Network, 1962-September 1968

2. Canadian Air and Precipitation Monitoring Program, September 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

[1] Prepared from information and data in the October 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for September 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.2	0.0	0.1	NS	NS
Coral Harbour	14	.1	.0	.0	27	2.1
Edmonton	30	.1	.0	.1	34	1.2
Ft. Churchill	30	.1	.0	.0	15	1.0
Ft. William	30	.2	.0	.1	37	1.7
Fredericton	30	.2	.0	.1	37	1.2
Goose Bay	30	.2	.0	.1	33	2.8
Halifax	29	.2	.0	.1	42	1.5
Inuvik	30	.1	.0	.0	122	.7
Montreal	25	.3	.0	.1	12	.7
Moosonee	30	.2	.0	.1	11	.5
Ottawa	30	.2	.0	.1	17	1.4
Quebec	30	.2	.0	.1	27	1.9
Regina	30	.1	.0	.1	54	1.8
Resolute	24	.1	.0	.1	24	.2
St. John's, Nfld	30	.1	.0	.1	33	1.0
Saskatoon	30	.2	.0	.1	24	1.2
Sault Ste. Marie	28	.2	.0	.1	35	2.9
Toronto	30	.2	.0	.1	20	1.6
Vancouver	30	.1	.0	.0	30	2.6
Whitehorse	30	.1	.0	.0	16	1.0
Windsor	30	.2	.0	.1	34	1.5
Winnipeg	30	.2	.0	.1	33	2.0
Yellowknife	30	.1	.0	.0	54	3.3
Network summary	690	0.3	0.0	0.1	34	1.6

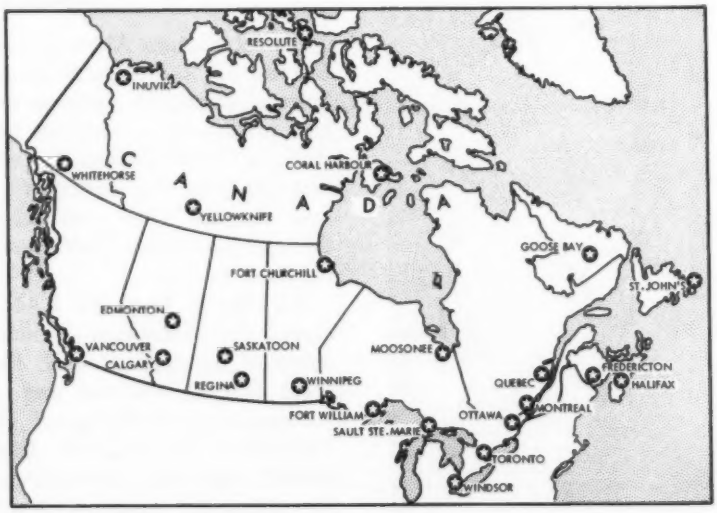

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program September 1968

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The September 1968 air monitoring results from the participating countries are given in table 3. The average concentration of gross beta radioactivity in all of the countries has decreased from the levels observed in August, but remain somewhat above pre-August levels.

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air. September 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina:				
Buenos Aires	NS			
Bolivia:				
La Paz	21	8.33	1.23	2.75
Chile:				
Santiago	29	2.02	.09	.63
Colombia:				
Bogata	16	.27	.02	.13
Ecuador:				
Guayaquil	18	1.57	.45	.78
Guyana:				
Georgetown	NS			
Jamaica:				
Kingston	18	.17	.04	.07
Peru:				
Lima	18	2.50	.57	1.50
Venezuela:				
Caracas	19	.92	.02	.26
West Indies:				
Trinidad	18	.51	.03	.23
Pan American summary	157	8.33	0.02	0.82

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no samples received.

4. Plutonium in Airborne Particulates and Precipitation, January–March 1968

Bureau of Radiological Health U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and analyses was initiated in November 1965 and August 1966, respectively. The results through December 1967 have been previously reported (*7–14*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded

Table 5. Plutonium in airborne particulates, January–March 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium-238 (fCi/m³)											
January	0.0049	0.0093	NS	0.0058	0.0131	0.0069	0.0124	0.0062	0.0117	0.0061	0.0068
February	.0089	.0138	NS	.0057	.0116	.0074	.0088	.0068	.0138	.0063	.0082
March	.0074	.0138	NS	.0104	.0102	.0108	.0086	.0018	.0117	.0068	.0151
Plutonium-239 (fCi/m³)											
January	.0136	.0155	NS	.0119	.0140	.0190	.0255	.0092	.0262	.0136	.0074
February	.0132	.0270	NS	.0199	.0276	.0138	.0236	.0143	.0358	.0148	.0245
March	.0282	.0307	NS	.0371	.0423	.0386	.0503	.0063	.0448	.0185	.0203
Plutonium-239/ plutonium-238											
January	2.78	1.67	NS	2.05	1.07	2.75	2.06	1.48	2.24	2.23	1.09
February	1.48	1.96	NS	3.49	2.38	1.86	2.68	2.10	2.59	2.35	2.98
March	3.81	2.22	NS	3.56	4.14	3.57	5.85	3.50	3.83	2.72	1.34

NS, no sample.

to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*14*).

The results for January through March 1968 are presented in tables 5 and 6. ND (not detectable) has been used to indicate samples containing plutonium–238 or plutonium–239 activities less than or equal to the appropriate minimum detectable activities (0.020 pCi and 0.015 pCi per sample for plutonium–238 and plutonium–239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

The data for plutonium–238 in precipitation have not been included in table 6 since the majority of the analyses produced results less than the minimum detectable concentration. The only exceptions were the February samples for Austin, Tex., and Honolulu, Hawaii, as follows:

	Depth (mm)	Concentration (pCi/liter)	Deposition (pCi/m²)
Austin	43	0.0039	0.17
Honolulu	22	0.0217	0.48

Table 6. Plutonium-239 in precipitation, January–March 1968[a]

	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm)								
January	47	61	NS	6	118	12	115	115
February	14	NS	NS	35	43	9	22	89
March	50	89	NS	52	61	13	35	105
Concentration (pCi/liter)								
January	ND	.0037	—	ND	.0034	NA	ND	.0036
February	.0188	—	—	.0062	.0096	ND	.0073	.0069
March	ND	.0162	—	.0061	ND	.0024	ND	.0115
Deposition (pCi/m²)								
January	—	0.23	—	—	0.40	—	—	.41
February	.26	—	—	0.22	0.41	—	.16	.61
March	—	1.44	—	0.32	—	—	—	1.21

[a] The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m²). One liter of water is collected when 1 mm of precipitation falls on 1-square meter.

NA, no analysis.
ND, nondetectable.
NS, no sample.

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(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(*7*) RUSSELL, J., H. LEVINE, R. SCHNEIDER. Plutonium in airborne particulates, November 1965 through March 1966. Radiol Health Data Rep 7:483–484 (August 1966).

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(*9*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, July–September 1966. Radiol Health Data Rep 8:108–109 (February 1967).

(*10*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, October–December 1966. Radiol Health Data Rep 8:288–289 (May 1967).

(*11*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, January–March 1967. Radiol Health Data Rep 8:534 (September 1967).

(*12*) LEVINE, H., W. P. KIRK, H. J. L. RECHEN. Plutonium and strontium–90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574–576 (October 1967).

(*13*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation and strontium–90 in precipitation, April–June 1967. Radiol Health Data Rep 8:662–663 (November 1967).

(*14*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July–December 1967. Radiol Health Data Rep 9:761–763 (December 1968).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Portsmouth Area Gaseous Diffusion Plant and the Savannah River Plant.

[1] Title 10, Code of Federal Regulations, Part 20. "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Portsmouth Area Gaseous Diffusion Plant [2] January–June 1968

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha particle, beta particle, and gamma-ray emitters.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 1. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1968, the waterborne beta-gamma radioactivity, airborne alpha and beta-gamma radioactivity and the background exposure remained essentially unchanged compared with the 1967 results. The waterborne alpha radioactivity increased slightly for January–June 1968. However, the overall results for alpha radioactivity in water equaled only 0.13 percent of the AEC concentration standards.

Average background dose rates remained unchanged from the first half 1967 values. In the calculations it is assumed that all of the dose rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

[2] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, First Half 1968" (August 19, 1968).

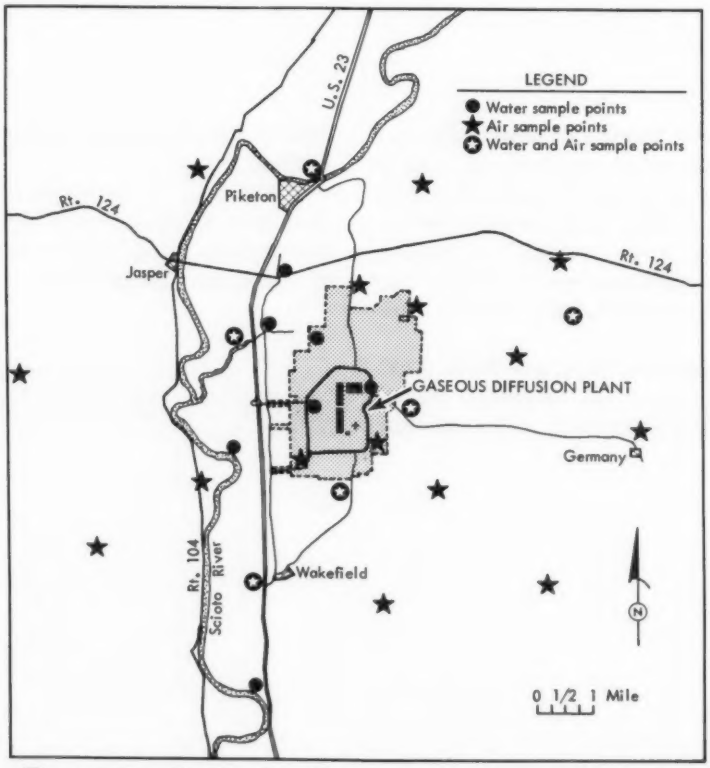

Figure 1. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 1. The external gamma-ray levels, measured at the air sampling locations shown in figure 1, are also summarized in table 1. The overall average concentrations and background exposure rates for 1967 and January–June 1968 are presented in table 2 as percent of standards.

Table 1. Environmental radioactivity, Portsmouth Plant, January–June 1968

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard[a]
Air:					
Alpha radioactivity, pCi/m³	126	0.4	<0.1	<0.1	<5.0
Beta-gamma radioactivity, pCi/m³	126	2.5	<0.1	.2	.02
Water:					
Alpha radioactivity, pCi/liter	54	1080	<0.5	26.3	.13
Beta-gamma radioactivity, pCi/liter	54	1440	<14.0	53.9	.27
Background dose rates[b], mrad/hr	126	.022	.009	.014	16.8

[a] The applicable AEC radiation protection standards are as follows:

Air (alpha radioactivity)	2 pCi/m³
Air (beta-gamma radioactivity)	1×10^2 pCi/m³
Water (alpha radioactivity)	2×10^4 pCi/liter
Water (beta-gamma radioactivity)	2×10^4 pCi/liter
External beta-gamma radioactivity	0.5 rem/yr (approx. 0.6 mrad/hr)

[b] Measurements were made with an open-shield Gieger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

Table 2. Comparison of average concentrations Portsmouth Plant, 1967 and 1968

Type of monitoring	Percent of AEC standard[a]			
	1967			1968
	First half	Second half	Calendar year	First half
Air				
Alpha radioactivity	<5.0	.23	<5.0	<5.0
Beta-gamma radioactivity	.02	.01	.01	.02
Water				
Alpha radioactivity	.09	.08	.08	.13
Beta-gamma radioactivity	.20	.28	.24	.27
Background exposure extrapolated to 3 feet above ground level	16.8	17.9	17.3	16.8

[a] See footnote (a) of table 1.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	January 1968
July–December 1967	July 1968

2. Savannah River Plant [3] January–June 1968

E. I. duPont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312-square miles along the Savannah River, 22-miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk, are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1968" (DPST 68-30-2).

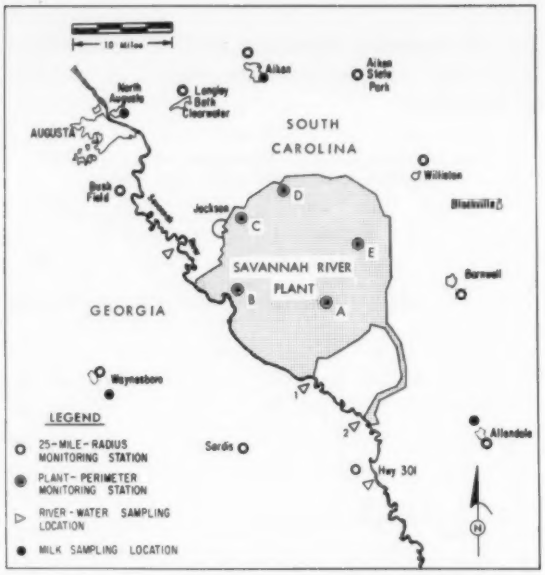

Figure 2. Environmental sampling locations, Savannah River Plant

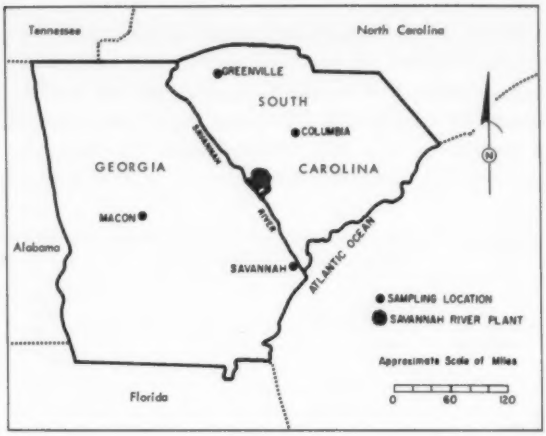

Figure 3. Distant air monitoring stations, Savannah River Plant

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 2). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by the Savannah plant would be detected regardless of the prevailing wind. All stations operate continuously. Four additional monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S. C., are so distant from the plant that the effect of Savannah River Plant operations is negligible; they are reference points for determining background radioactivity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and Savannah River Plant releases.

The small amount of filterable beta radioactivity released to the atmosphere, primarily from fuel separation areas, was obscured by fallout. The influence of the weapons tests which resumed in September 1961 is shown in figure 4. The rise in early 1964 was the result of the anticipated spring increase in the mixing of the stratospheric debris into the troposphere. The average beta radioactivity concentration in air increased from 0.03 to 0.15 pCi/m^3 during January–June 1968.

Radioactivity in air, determined from filter analyses, is shown in table 3. The January–June 1968 concentrations of filterable beta radioactivity (0.15 pCi/m^3) and alpha radioactivity (0.0008 pCi/m^3) in air were 0.15 and 1.1 percent of the respective MPC's. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.1 percent of the MPC.

Deposition of fallout during January–June 1968 totaled 21 nCi/m^2 at the plant perimeter locations and 17 nCi/m^2 at 25-mile radius locations; comparable values for the last half of 1967 were 1.2 and 1.0 nCi/m^2. Deposition at each sampling location is presented in table 4.

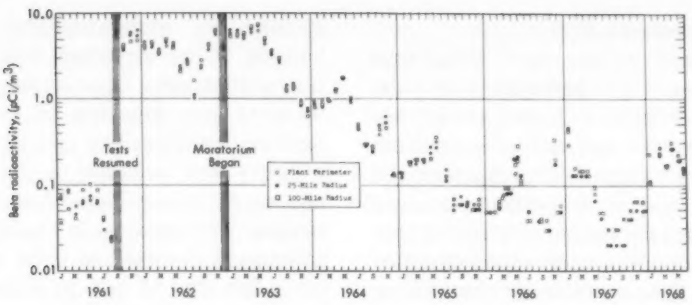

Figure 4. Influence of weapons tests

Table 3. Radioactivity in air, Savannah River Plant, January–June 1968

Filter analysis	Average concentrations (pCi/m³)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters[a] (multiply by 10^{-2})																	
Maximum	1.5	1.7	1.4	1.3	1.2		1.8	2.3	2.1	2.2	1.8	1.5	2.2	2.5	1.9	2.6	
Minimum	ND	ND	.4	ND	.4		.3	.3	.6	ND	ND	.3	.3	.4	.6	.4	
Average	.9	.9	.9	.8	.7	0.8	.9	.9	1.0	.8	.8	.9	.8	.8	.9	.9	0.9
Nonvolatile beta-particle emitters[b]																	
Maximum	.35	.27	.30	.34	.31		.35	.42	.28	.28	.31	.36	.27	.31	.30	.29	
Minimum	.06	.02	.06	.09	.07		.06	.09	.08	.06	.05	.06	.06	.07	.08	.09	
Average	.21	.18	.19	.19	.20	0.19	.20	.21	.19	.18	.19	.20	.18	.19	.19	.19	0.19
Specific radionuclides (averages)	Composite sample						Composite sample										
Strontium–89, –90	0.01						0.01										
Cesium–137	.01						.01										
Cerium–141, –144	.06						.05										
Zirconium-niobium–95	.08						.06										
Ruthenium–103, –106	.05						.09										
Maganese–54	.01						.01										
Berylliun–7	.14						.15										

[a] Sensitivity of analysis—3.0 x 10^{-4} pCi/m³; ICRP Maximum Permissible Concentration: 0.07 pCi/m³.
[b] Sensitivity of analysis—0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.
ND, nondetectable, less than sensitivity of analysis.

Table 4. Total fallout deposited, Savannah River Plant, January–June 1968

Radionuclide	Deposition (nCi/m²)															
	Plant perimeter locations						25 mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha[a]	7.3	9.6	6.1	17.9	19.3	12.0	9.2	5.2	15.7	5.8	5.7	16.0	3.1	13.8	9.0	13.5	9.7
Strontium–89	1.0	.3	ND	.8	.3	.5	.6	.7	1.2	.7	.3	.3	.5	.4	.3	.1	.5
Strontium–90	.6	.8	.8	.9	.7	.8	1.2	.8	.7	.9	1.0	1.1	.7	.9	1.1	1.0	.9
Cesium–137	1.1	1.9	1.3	1.4	1.6	1.5	1.5	1.5	1.0	1.3	2.3	2.2	1.5	1.6	1.3	1.8	1.6
Cerium–141, –144	6.8	5.9	9.2	5.2	6.1	6.6	10.3	4.2	5.6	8.2	8.0	6.9	4.6	2.9	6.1	6.7	6.4
Zirconium-niobium–95	9.1	7.7	11.3	6.6	9.0	8.7	14.1	4.4	6.9	13.8	13.6	10.4	7.3	4.7	9.3	10.4	9.5
Beryllium–7	24.6	36.6	47.4	32.2	38.4	35.8	22.8	11.6	31.0	30.9	37.1	36.0	11.8	22.2	18.5	28.8	25.1
Ruthenium–106	ND	ND	2.1	ND	1.1	0.6	2.8	ND	ND	1.8	2.0	ND	1.7	ND	ND	ND	.8

[a] Multiply by 10^{-3}.
ND, nondetectable, less than sensitivity of analysis.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green *(Vaucheria)* and blue-green *(Phormidium)*, were collected weekly upstream from, adjacent to and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station 3-miles upstream from the Savannah River Plant, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas, cerium–141,–144, chromium–51, zirconium-niobium–95, manganese–54, zinc–65, and cobalt–60, were detected less frequently. Also, radiostrontium (maximum, 18 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 31 pCi/g, wet weight) was detected in the flesh tissue. Phosphorus–32 was detected less frequently in these tissues. The maximum concentrations of phosphorus–32 detected in bone and flesh tissues of river fish was 36 pCi/g; phosphorus–32 in flesh tissue was less than the sensitivity of analysis (2 pCi/g).

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 5). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort

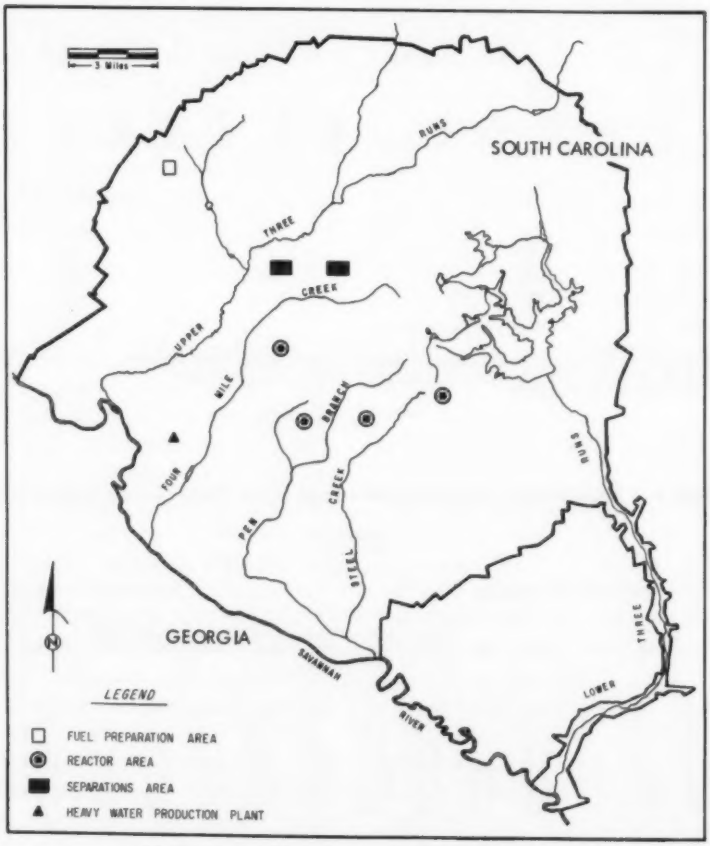

Figure 5. SRP production and effluent steams

County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the Savannah River Plant. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.0 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Average concentrations of specific radionuclides found in river water during January–June 1968 appear in table 5.

Table 5. Average concentration of radionuclides in Savannah River water, January–June 1968

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	800	9,500	0.31
Ruthenium-103, -106	3.2	ND	ND	< .03
Cerium-141, -144	2.5	ND	ND	< .02
Cesium-134, -137	.6	ND	.9	.004
Neptunium-239	2.2	ND	ND	< .002
Barium-lanthanum-140	1.6	ND	ND	< .01
Zirconium-niobium-95	.5	ND	ND	< .001
Chromium-51	4.3	ND	11.8	.0006
Strontium-89	.3	ND	2.6	.09
Iodine-131	.5	ND	ND	.16
Strontium-90	.01	.6	1.0	.25
Cobalt-60	1.4	ND	ND	< .003
Zinc-65	1.1	ND	ND	< .001
Manganese-54	.4	ND	ND	< .0004
Sulfur-35	10.0	ND	32	.05

ND, nondetectable, less than sensitivity of analysis.

Tritium, sulfur–35, and trace amounts of cesium–137, chromium–51, strontium–89, and strontium–90, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from the Savannah plant. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 5,000 pCi/liter (0.2 percent of the MPC) during the 6-month report period. The annual radiation dose of an individual in this population from the consumption of water containing the very low concentration of tritium is only 0.4 mrem. The radiation dose was determined by analysis of urine (38 samples) collected from Beaufort residents during January–June 1968.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water moderator in the reactors. Sulfur–35, also a beta-particle emitter and the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable sulfur (a component of the ion exchange resin used in the moderator-purification system in reactor areas). The tritium and sulfur–35 concentrations in river water averaged 0.31 and 0.05 percent of the MPC, respectively.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route. (These are not designated on figure 2). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.1 pCi/g during the last half of 1967; gamma-ray emitters averaged 21 and 31 pCi/g, respectively, as compared to 4.8 and 5.3 pCi/g for the last half of 1967.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant, as shown in figure 2. Samples which were collected biweekly were analyzed for tritium and radioiodine. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1968 are shown in table 6.

Table 6. Radioactivity in milk from local dairies Savannah River Plant, January–June 1968

Distributing points	Concentration (pCi/liter)							
	Tritium[a]			Strontium-90[b]		Iodine-131[c]		
	Maximum	Minimum	Average	March	June	Maximum	Minimum	Average
Aiken	3,000	ND	ND	15	23	ND	ND	ND
North Augusta	9,000	ND	ND	15	25	ND	ND	ND
Waynesboro	5,000	ND	ND	10	NS	ND	ND	ND
Major distributors[d]	3,000	ND	ND	15	15	ND	ND	ND

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter.
[d] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Average concentrations of the radionuclides in milk (17 pCi/liter for strontium–90 and <5 pCi/liter for iodine–131, compared to 12 and <5 pCi/liter, respectively, during the last half of 1967) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of concentrations of 3,000 pCi/liter (<0.1 percent of the MPC for water).

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1968 data (shown in table 7), are characteristic of measurements observed at individual stations for the past several years.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	February 1968
July–December 1967	June 1968

Table 7. Environmental gamma radiation, Savannah River Plant, January–June 1968

Filter Analysis	Exposure (mR/day)															
	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Hwy 301	Average
Maximum	0.29	0.29	0.28	0.24	0.59		0.71	0.33	0.23	0.23	0.43	0.44	0.29	0.39	0.31	0.28	
Minimum	.07	.07	.07	.06	.07		.03	.08	.09	.08	.03	.07	.04	.09	.07	.07	
Average	.19	.18	.19	.16	.21	0.19	.25	.18	.16	.18	.21	.20	.12	.19	.20	.18	0.19

Erratum

The June 1968 data for the Mexican Air Monitoring Network presented in the October 1968 issue of *Radiological Health Data and Reports*, pp. 575–576, is incorrect. The correct data will be presented in the February 1969 issue.

Reported Nuclear Detonations, December 1968

The U.S. Atomic Energy Commission announced three underground nuclear tests for the month of December 1968.

On December 8, 1968, the Atomic Energy Commission conducted a nuclear cratering experiment at its Nevada Test Site. The experiment was part of the Commission's Plowshare program to develop peaceful uses of nuclear explosives.

The experiment consisted of the detonation of a minimum-fission nuclear explosive with a yield of about 35 kilotons (equivalent to 35,000 tons of TNT). The explosion took place at a depth of 350 feet underground in hard rock and preliminary estimates indicated that it resulted in a crater with a diameter of about 850 feet and a depth of about 200 feet.

The experiment, called Project Schooner was part of the AEC's program to develop nuclear excavation technology and will provide information about cratering effects in hard rock.

December 12, 1968 a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at the Nevada Test Site.

The U.S. Atomic Energy Commission announced that they conducted a nuclear test of about a megaton in yield on December 19, 1968.

Detection of a Soviet nuclear test was announced by the U.S. Atomic Energy Commission on December 18, 1968. Seismic signals originating from the Soviet nuclear test area in the Semipalatinsk region were recorded. The signals were equivalent to those of a nuclear test in the low yield range (less than 20 kilotons TNT equivalent).

Also, on December 27, 1968, the Atomic Energy Commission detected a nuclear explosion in the general area of the Chinese nuclear test site at Lop Nor. Preliminary estimates indicated a yield of approximately 3 megatons TNT equivalent.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIATION DOSES TO CHILDREN'S THYROIDS FROM IODINE–131 IN MILK. *Robert N. Neill and Paul B. Robinson. Radiological Health Data and Reports, Vol. 10, January 1969,* pp. 1–9.

Measurements of idoine–131 in milk taken since 1957 were used to estimate the average cumulative radiation doses to children born and living in selected U.S. cities. The cumulative doses were summed for a cohort (born in a particular year and city) from quarterly doses calculated by varying thyroid weight, uptake factor, and milk consumption, as a function of the age of the child and concentrations of iodine–131 in milk as a function of time and location. Average values of these variables were selected for each quarter.

For a given concentration of iodine–131 in milk, the population receiving the greatest dose are milk-drinking infants of 6 to 11 months of age. Considerable variation was found to exist in cumulative doses for children raised in different cities. Within a particular city, there is a large variation in thyroidal doses for children born in different years.

The largest doses were 1,750 mrem and 1,625 mrem, received by children born in 1957 in St. Louis and Salt Lake City. At the time of the cessation of weapons testing in 1963, the average child of 6 years of age in four of the five U.S. cities where data are available had received man-made cumulative thyroidal doses greater than his cumulative natural dose. Because of the relative absence of iodine–131 in the environment for the past 4 years, the children of today whose cumulative fallout exposure exceed their natural background exposure are those born in 1957 in Cincinnati, Salt Lake City and St. Louis. From the results obtained from these three out of five cities for which data are available, it is apparent that children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, and possibly in some other unmonitored areas of the United States, have cumulative thyroidal doses from iodine–131 following atmospheric weapons tests greater than their cumulative natural background doses, but less than the cumulative dose at an annual dose rate equal to the Radiation Protection Guide (RPG) during the same period.

KEYWORDS: children, doses, idoine–131, milk, thyroids, United States.

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